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2016

Dec 2016
Issue 435

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- MONSTER MSI GAMING LAPTOP: IT'S GOT TWO DESKTOP GPUS!
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- IPv6 & IPv4
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- Works with VigorACS SI management system

Vigor2860 Series



Vigor2860Ln



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- 32 x VPN & 16 x SSL-VPN tunnels with VPN Management
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Vigor2925Ln

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- IPv6 & IPv4
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- IEEE 802.11ac WLAN for Vigor2925ac
- VoIP (V model)



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FIPP

Is webcam hacking paranoia justified?

Should you cover your webcam with tape?
APC's editor weighs in.

About a year ago, one of my friends purchased a webcam cover for her MacBook – a little plastic slider that sticks over the lense and can be opened or shut to reveal the camera. I didn't give it too much thought at the time – I run antivirus on all my machines, so I assumed I was protected. But with people like the CEO of Facebook and the director of the FBI both adopting the practice (the law-enforcement agency has covers installed on all its laptops), it's worth delving a bit deeper into.

It turns out that there's a burgeoning industry for hacked webcams, with dedicated tools built specifically for the purpose of hijacking them. Usually, these get installed via phishing emails, where a user clicks on a link that surreptitiously downloads and installs the monitoring app without their awareness. Back in 2014, the FBI busted a number of hackers using a program called Blackshades, which had apparently infected over half a million PCs.

While most antivirus programs should identify and quarantine threats like these, there's no such thing as a 100% bulletproof security suite – and there are often few signs that you've been infected. These secret monitoring apps don't activate a camera's recording lights and women, it seems, are the more highly-prized targets, according to a 2013 report filed by the BBC (see www.bbc.com/news/uk-22967622).

One telltale sign can be sudden battery drain, but as there are many things that can cause that symptom, it's by no means a definitive way to

tell. In short, this is one area where you might want to heed the warnings and invest in a cheap webcam cover – you can find them on eBay for under \$5 – or at the very least, put some electrical tape over your laptop's lense.

LINUX VS WINDOWS

Over the last few months, we've received quite a few requests from readers asking for a 'Windows vs Linux' feature – something to make switching to the open-source OS a little easier on newcomers. Linux is a lot simpler to get to grips with today than it was 10 years ago, but many of us are still hesitant about jumping to an entirely new OS, understandably.

This month, we've pieced together a sort of beginners guide to Linux, largely focused around Mint OS, that we hope covers most of the questions a potential switcher could have – and if there's anything we've missed, you can always shoot us your questions to apcmag@futurenet.com.

I count myself as a Linux dabbler – I've got it installed on a media PC at home, but am by no means an expert. Some of the revelations in Mr Peers' feature on page 70 were, therefore, quite informative when it came to filling in the blanks – so don't worry if you feel a bit nonplussed by some elements of Linux; you're in good company! ■



DAN GARDINER
EDITOR-IN-CHIEF
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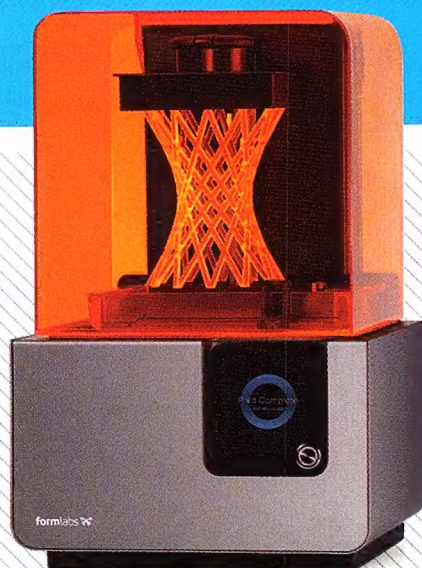
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When it comes to online community reviews, digital storefronts need to clamp down on dodgy reviewers.

"Even manly men should be able to use one of these without feeling too emasculated." Dell XPS 13, page 23.



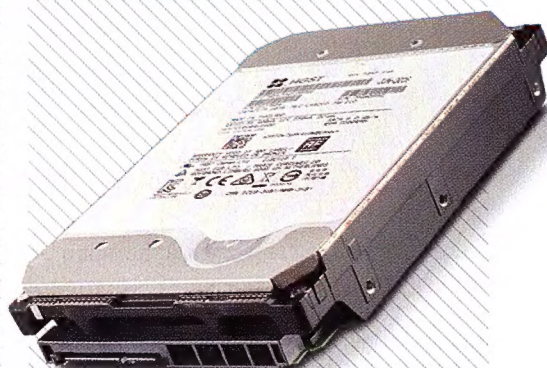
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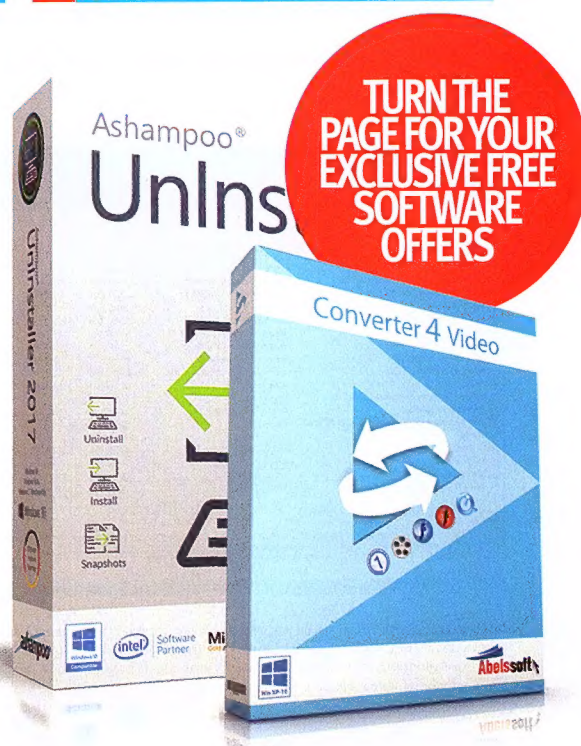
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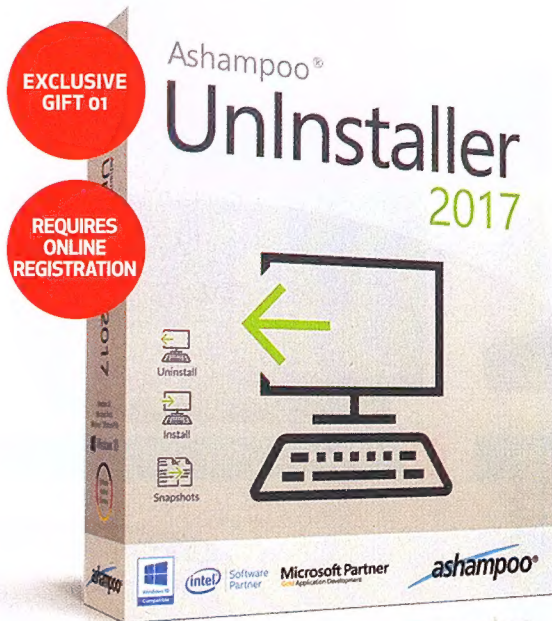


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ISSUE 435, DECEMBER 2016

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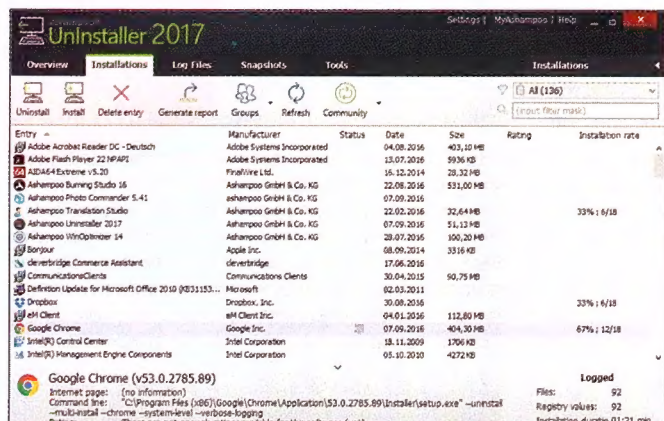
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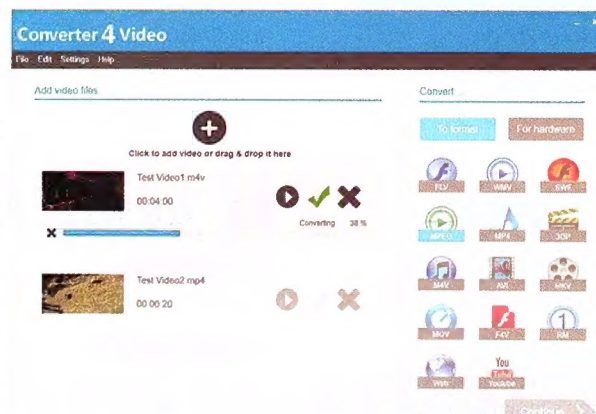
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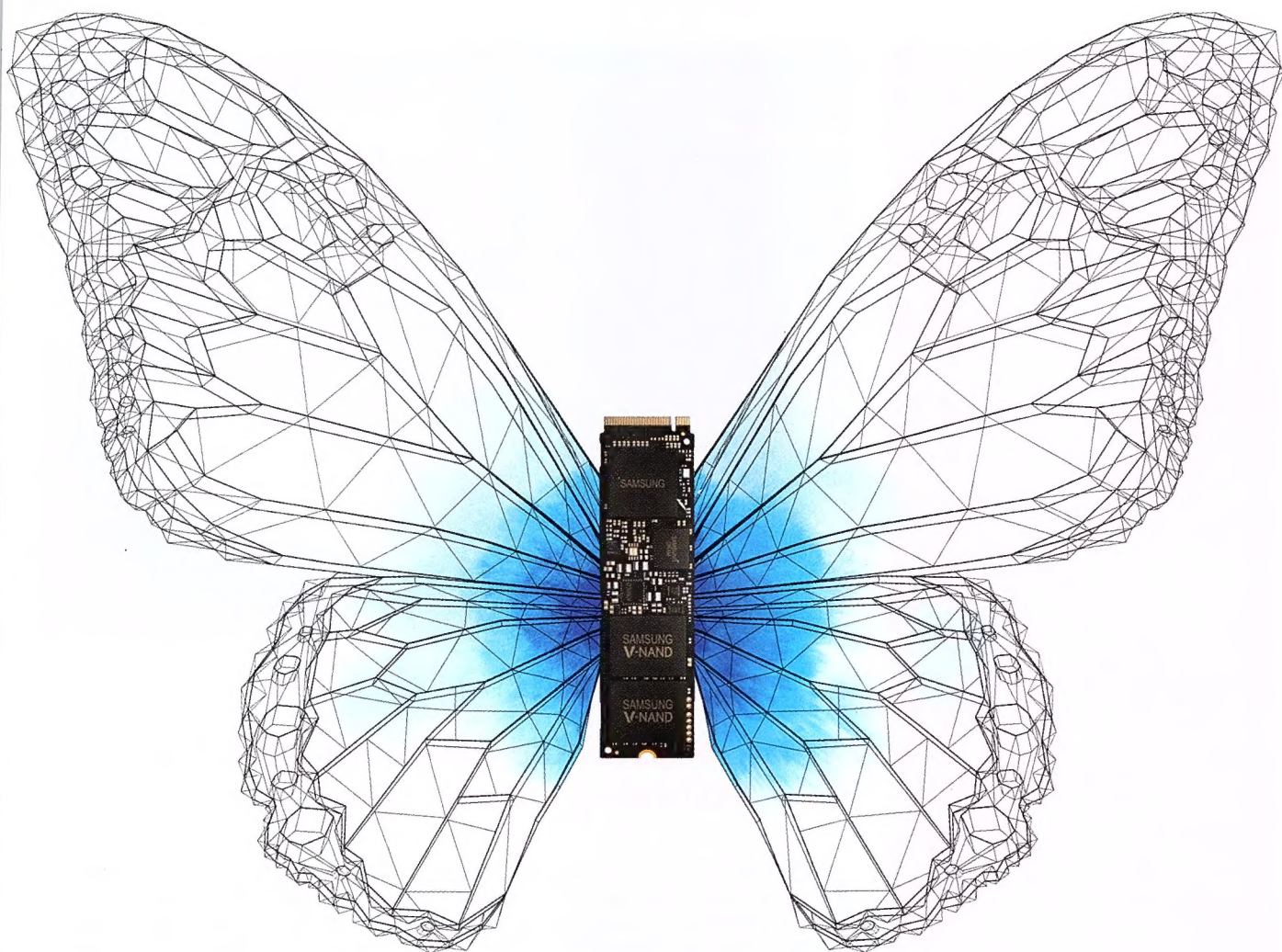
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SAMSUNG



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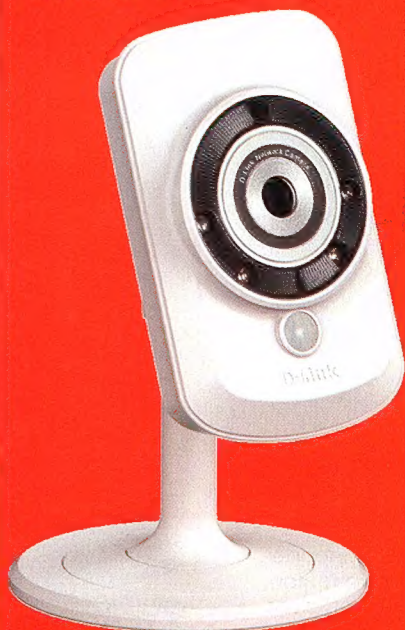
Available now in 256GB & 512GB at Specialist Retailers | www.samsung.com/au/ssd

*Performance benchmark product : 950 PRO(512GB)



Massive IoT-powered botnet behind world's biggest DDoS attack AND LAME PASSWORDS ARE TO BLAME.

In September, security journalist Brian Krebs had to take down his website after it was bombarded with a slew of traffic thrown against it by hackers. The attack was powered by a botnet made up of an estimated half a million to a million hacked devices, most of which were internet-connected cameras. These were combined to launch a distributed denial of service attack (DDoS) to Krebs's site. The release of the source code for this malware, called Mirai, by a hacker named Anna-senpai early in October gave cybercriminals an easy way to launch attacks. It's also allowed security experts to track the hackers' activities and map their botnet. According to Imperva, a company that provides protection against DDoS attacks, the network of Mirai-infected devices has spread to 164 countries. But a researcher going by the sobriquet MalwareTech puts that number at 177 countries. Mirai is a simple piece of malware that spreads quickly and effectively, targeting Internet of Things (IoT) devices using predictable passwords like 'admin', '12345', 'password' and 'guest'. SS



Knockoff mania!

Chinese manufacturers are swiping Kickstarter ideas and beating them to market.

China is infamous for manufacturing cheap knockoffs of pretty much any consumer product that hits the market. But lately, they've apparently started getting one step even further ahead, and have taken to ripping ideas off Kickstarter, manufacturing a copy of still-in-the-works products and then selling them — sometimes even before the original design's crowdfunding window closes. Yekutiel Sherman, an Israeli entrepreneur, spent a year designing a selfie stick that collapses into a smartphone case — the Stikbox, pictured above — only to find Chinese vendors selling his product on AliExpress for a fraction of the original price tag a week after his product went live on Kickstarter. Sharmishta Sarkar

Julian Assange's internet access revoked for WikiLeaks 'meddling' with US elections

BUT NOT HIS ASYLUM STATUS.

Having lived at the Ecuadorian Embassy in London since 2012 when he was granted asylum by the nation, the founder of WikiLeaks recently said that he had lost internet access. Assange found himself cut off after his organisation published emails containing speeches Democratic presidential candidate Hillary Clinton made to investment firm Goldman Sachs. In a statement, the Ecuadorian Government said it "respects the principle of non-intervention in the internal affairs of other states. It does not interfere in external electoral processes, nor does it favour any particular candidate." That said, it reaffirmed the asylum granted to Assange 4 years ago. Sharmishta Sarkar



Hello, Mr Anderson...

IT BEGINS: YOUR NEXT BOSS COULD BE AN AI.

Teito, a Finnish IT company, has added a software program to its leadership team. Called Alicia T, this bot will participate in team meetings and vote on business matters. But it is unclear how the AI would contribute towards the business or why its surname had to be an initial. In 2014, an investment firm in Hong Kong announced they had also appointed a program called VITAL to its board of directors. **SS**

'Boring' VR could help treat mental illness

A POSSIBLE WITHDRAWAL FROM ADDICTIVE OPIOIDS.

Narcotic analgesics might soon be replaced by virtual reality gaming to treat chronic pain and mental distress. By using the existing Samsung Gear VR hardware, AppliedVR has produced software that provides distraction from pain. Patients play 'boring' games they cannot lose, like shooting bears with balls or throwing food at hungry animals, but players have described these games as 'mesmerising'. **SS**

Beware of strangers bearing USB thumb drives

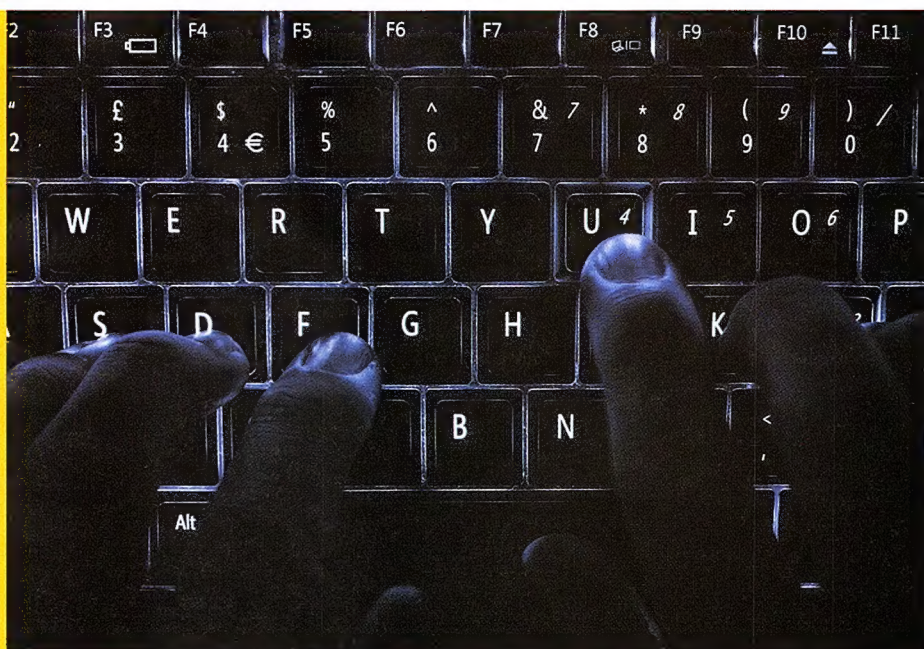
THEY COULD BE INFESTED WITH MALWARE.

The Victoria Police has warned Pakenham residents to avoid inserting into their computers any USB thumb drives they may find in their letter boxes. Cyber criminals have been targeting residents in the area with malware-filled drives, some of which reportedly serve "fraudulent media streaming service offers, as well as other serious issues". **SL**

100 piracy-oriented sites could soon be blocked in Australia

A PIRACY CRUSADE.

Calling the pirates who facilitate the running of illegal download sites 'leeches', Village Roadshow boss Graham Burke said that, once legislation was in place for site-blocking, the movie industry could set the precedent for taking down piracy websites. With the legal framework in place, plans could be implemented to take down at least 100 illegal download sites. **SS**



Yahoo! hacked, at least 500 million accounts affected

Oh, and the search giant probably also gave the NSA a backdoor to spy on your emails...

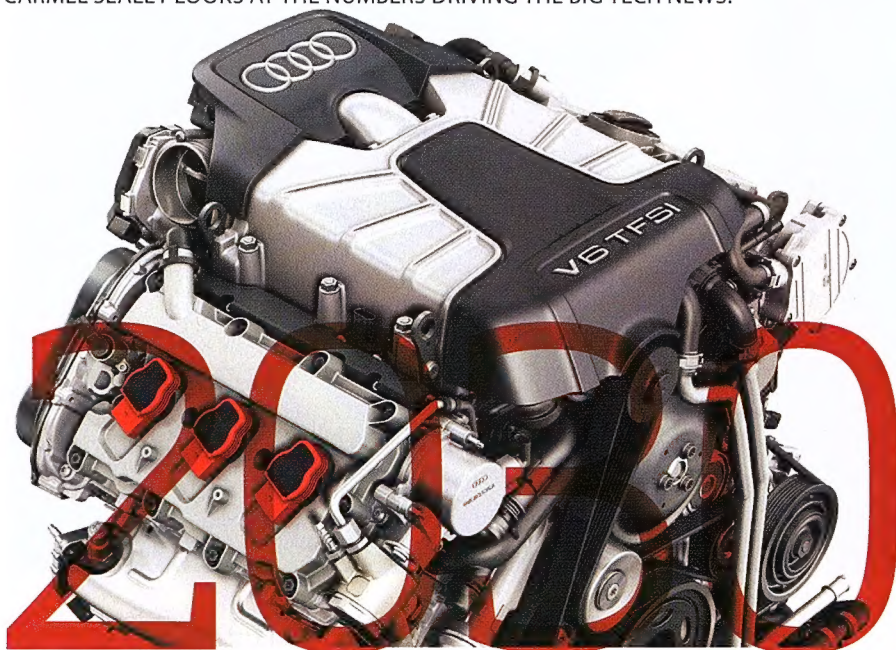
Though it's only come to light recently, it's been revealed that an enormous hack that saw around 500 hundred million Yahoo user accounts stolen by hackers actually took place two years ago. Yahoo, which only noticed the hack weeks before it was made public, has disclosed that names, phone numbers, encrypted passwords and emails were among the private details pinched. Thankfully, Yahoo has confirmed that bank information was not taken by the thieves. Though the incident has been divulged by the search engine company, questions surrounding the hack remain. Yahoo has stated that the perpetrator is a "state-sponsored actor," though it has not contributed proof to support the claim. A recent report by Reuters has claimed that Yahoo created a program to search all its users' emails at the behest of US intelligence officials, leading some to believe the incidents are connected. However, information security firm InfoArmor says the hackers are definitely of the criminal variety, having tracked what it believes are the culprits for three years. **Stephen Lambrechts**

US gov't directly accuses Russia of DNC hack
MULLING 'PROPORTIONAL RESPONSE' TO CYBER ATTACK.

WikiLeaks published nearly 20,000 hacked emails from top Democratic National Committee officials in July, throwing the US political party's convention into chaos. More recently, the voter registration system in nearly half the country was infiltrated, with US voter info being leaked not just from government systems, but from private contractors as well. For a while, security experts have laid the blame at Russia's doorstep, but the US intelligence agencies have only recently publicly accused the Russian Government. US officials said the infiltration of the voter registration system originated from servers operated by a Russian company. The White House Press Secretary said President Obama had numerous response options at his disposal. The President had, in the past, discussed the US Government's capabilities in defending their interests in cyberspace as well as launching offensive attacks on other countries. Speaking to reporters, the Press Secretary said, "We obviously will ensure that a US response is proportional. It is unlikely that our response would be announced in advanced." A Russian response to these accusations is expected. **Sharmishta Sarkar**

technotes

» CARMEL SEALEY LOOKS AT THE NUMBERS DRIVING THE BIG TECH NEWS.



THE YEAR GERMANY PLANS TO HAVE FULLY BANNED THE INTERNAL COMBUSTION ENGINE.

Germany's car industry is the third largest in the world, including big brands like BMW, VW, Audi, Porsche and Mercedes-Benz. However, the push towards carbon-neutral transport around the world has motivated Germany's Bundesrat (the federal council — not to be confused with the Bundestag, the parliament) to vote on banning the internal combustion engine. While the result was non-binding, the vote passed with both sides of parliament in agreement, demonstrating Germany's will to move towards fossil-fuel-free vehicles. The country now hopes to implement binding legislation to ban the internal combustion engine by 2030, with further aims to go full electric by 2050.



US\$1.5M

HOW MUCH A BROKER IS WILLING TO PAY FOR IPHONE SECURITY EXPLOITS.

Zerodium is a broker of security exploits keen to know about flaws in iPhones and iPads — so keen, in fact, that it's willing to pay up to US\$1.5 million for successful attack methods. After purchasing the exploits, Zerodium (and other brokers like it) then sell them on to government bodies that supposedly use them to spy on criminals. That astonishing amount is reflective of the security advancements made by Apple software developers, making the OS harder to crack. In comparison, Apple's own bounties are a mere fraction of the price, at US\$250k.



\$4.1B

HOW MUCH BUSINESS SAMSUNG STANDS TO LOSE DUE TO THE NOTE 7 DEBACLE.

As of October, Samsung announced the full halt of its Galaxy Note7 phones and extended a worldwide recall of all devices, including replacements, after instances of exploding batteries. This disaster for the South Korean company will cost them an estimated \$4.1 billion, with the likelihood of greater losses due to consumers looking elsewhere for smartphones and possible legal cases. Samsung hopes to recover some of its profits by now focusing on selling its Galaxy S7 and S7 Edge devices.



42%

PERCENTAGE OF VIDEO PIRACY NOW COMING FROM ILLEGAL STREAMING.

Streaming content is arguably easier than buying it digitally, so it makes sense that the online pirates of our world would also turn to streaming illegally-obtained content rather than relying solely on torrenting. According to the 'Millennials at the Gate' report from Anatomy Media, illegal streaming websites came out on top as the main source of online video piracy at 42%, closely followed by mobile apps at 41%.

US\$20 million

HOW MUCH SAMSUNG MAY HAVE TO PAY APPLE.

Apple has taken Samsung to court time and time again over design patent infringements from as far back as 2011. In October this year, Samsung was told that it would have to pay Apple US\$120 million for three patent violations ('slide-to-unlock', autocorrect and quick-link features in its smartphones), eight months after it was told by a different panel that it would not need to pay the sum. Interestingly, a separate case between the two tech giants is currently taking place in the US Supreme Court that might prevent future feuds over patents if a decision is reached.

technotes

» CARMEL SEALEY WADES INTO A CURRENT NEWS TOPIC TO TAKE A CLOSER LOOK



Paying the troll toll

Who's that tripping over my bridge?

In this new monthly news feature, we take a deeper look at a trending topic through the lens of five related stories that help illuminate the bigger picture. 'Trolling' is the act of sowing discord online often by inciting arguments with the intent to simply provoke some sort of negative emotional response, mostly from strangers. While many perpetrators believe trolling is harmless fun, the effects of such behaviour can be felt quite deeply by those targeted by trolls, often relentlessly. Online bullying is a rapidly growing problem in the digital age, one that is hard to tackle, as many lawmakers around the world are discovering. So when does trolling become more than harmless?

Infamous online conservative offers to save 4chan message board

4CHAN IS AN ONLINE MESSAGE BOARD THAT ALLOWS USERS TO POST WHATEVER THEY LIKE AND ANONYMOUSLY, BE IT DEATH THREATS, PORN, OR VERBAL ABUSE.

The current CEO, Hiroyuki Nishimura, has said the site could soon shut down due to bankruptcy — which would be no loss to the majority of the online community. Milo Yiannopoulos is a Trump-supporting columnist who was recently banned from Twitter for encouraging the continued abuse of actress Leslie Jones (recently of *Ghostbusters* fame). This all-round great guy is thinking of stepping in to save 4chan with an unnamed "wealthy financier". In the name of free speech or free hate speech, we wonder...

Counsellors see increase in children affected by online bullying

CHILDREN OFTEN FIND IT DIFFICULT TO TALK TO THEIR FAMILY OR FRIENDS ABOUT BULLYING, FEELING A SENSE OF EMBARRASSMENT OR SHAME.

In many ways, cyberbullying is worse than what may occur to kids in the playground, due to its anonymous nature allowing offenders to be crueler in their verbal abuse and also invading the victims' homes through social media. The UK's leading child-based charity NSPCC reported that cyberbullying was in the top three reasons children contacted counselling service ChildLine during 2015/16 with over 11,000 cases. In all, ChildLine received a 5% increase in calls and emails from children over the last year.



Making trolls argue with bots is an ingenious use of AI

ARGUETRON IS A TWITTER BOT CREATED BY SARAH NYBERG FOR THE SOLE PURPOSE OF PLAYFULLY LURING TROLLS OUT OF THE WOODWORK.

By tweeting progressive opinions every ten minutes under the guise of someone called Liz, it acts like a spider in a web, waiting for a fly to catch itself. And it will only tweet at you in response to one of your own tweets to it, so it's never the instigator. Some of its tweets include "Fox News only has bad opinions", "vaccinate your kids", "cops shooting unarmed people should be prosecuted for murder" and "I can't believe Pauline Hanson fans exist".

The Dark Triad of online trolls

WHY DO TROLLS TROLL?

Due to a 2014 study on ScienceDirect.com, 'The Dark Triad of personality' is a likely reason behind the occurrence of trolling. The triad consists of narcissism (an inflated sense of self-worth), Machiavellianism (manipulating others) and sadism (inflicting pain on others). The study revealed that individuals with higher levels of these three traits were more likely to troll, and a complementary study found that 'negative social potency' (self-serving behaviours that create social discord) was also a motivation for online trolling.

The UK is looking to pass laws that will see trolls face jail time

TROLLS WHO PARTICIPATE IN "GROSSLY ABUSIVE" BEHAVIOUR ONLINE COULD SOON FACE PROSECUTION, ACCORDING TO THE DIRECTOR OF PUBLIC PROSECUTIONS IN THE UK.

While Alison Saunders does make it clear that any such laws would not stifle free speech, she emphasised that: "If you are bullying or harassing people online, then we will prosecute in the same way as if you did it offline." She also went on to say that they would consider guidelines on misogynistic online hate crimes as well. Australia currently has no cyberbullying legislation.

tech

» NEW TECH BRIEFING

PC manufacturers are racing to join in on the HDR phenomenon.

What HDR means for PC gaming

HDR is coming. But what is it and how does it apply to your graphics card, monitor and PC games? James Norris explains.

Everyone's talking about 'HDR' these days, and if you pay attention to the video settings in PC games, you might be wondering, 'What's the big deal? That's been around for years!' Well, I have some news for you. All those 'HDR' checkboxes and options you've seen in games since *Half-Life 2*? Turns out that's not really HDR. That option marked 'HDR' in the camera app on your smartphone? That's not really HDR either.

Lost? Don't feel bad; when it comes to misconceptions about HDR, that's just the tip of the iceberg. So just what is HDR and what can it do for PC gaming?

HDR, or High Dynamic Range, is an umbrella term for a series of standards designed to expand the colour and contrast range of video displays far beyond what most current hardware can produce. Despite what you may have heard during the headlong push to 4K, resolution is pretty far down

the list when it comes to image quality. Beyond roughly 110dpi under current Windows UI scaling limitations, the number of pixels starts to matter much less than what you do with them.

Contrast, brightness and vibrant colour all become more important to image quality once resolution needs are met, and improving these is what HDR is all about. It's not an incremental upgrade either; HDR's radical requirements will mean new hardware for almost everyone and a difference you don't need a benchmark or trained eyes to perceive.

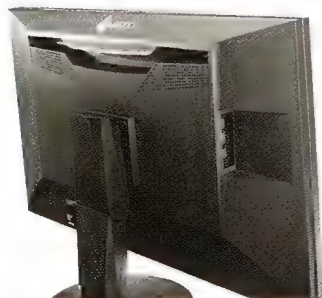
For starters, HDR specs require a minimum 1,000cd/m² or nits of brightness for LCD screens to adhere to the new 'Ultra-HD Premium' standard. High-end desktop gaming monitors, which top out around 300–400 nits in brightness, don't come close to making the cut. Good laptops don't fare much better, since they only push about 100 nits or so more. Even phones, with their

sci-fi sunlight-viewable screen technology, only reach about 800 nits.

Colour also gets a makeover with HDR specs requiring a full 10- or 12-bit colour space per channel, which is fully accessible across the OS and managed via a set of active standards. Most PC displays only provide 6- or 8-bit colour per channel.

Currently, PC monitors that support wide gamut colour, or WGC, generally reserve compatibility for professional use, such as photo editing or medical research applications. Games and other software simply ignore the extra colours and often wind up looking misadjusted. HDR standards avoid the confusion by including metadata with the video stream that helps manage the colour space properly.

To help handle all the extra data, HDR also ushers in HDMI 2.0a as a minimum display connector requirement; a long overdue upgrade



The Eizo ColorEdge professional series supports WGC but isn't close to HDR compatibility.



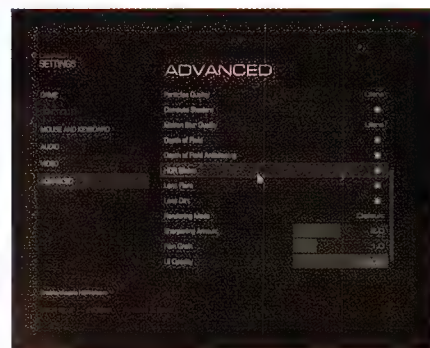
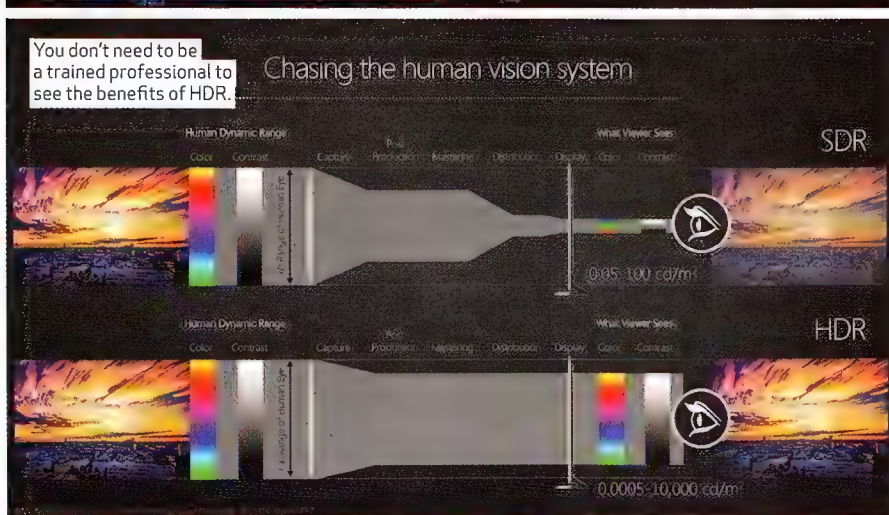
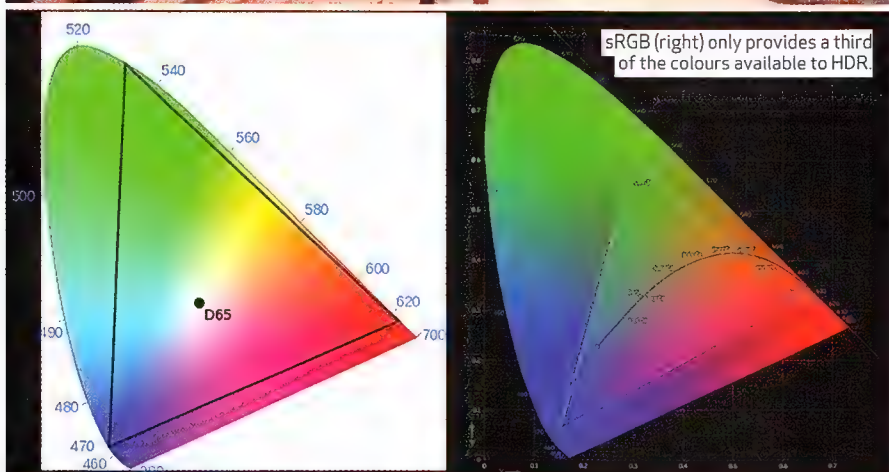
Hardware HDR has already arrived for consumers in the high-end TV market.



A currently growing library of HDR titles makes side-by-side comparison easy.



HDR (left) and standard (right). Nvidia is busy adding HDR support to Rise of the Tomb Raider on PC.



Nope, that's not real HDR. Sorry.

on the ubiquitous low-bandwidth HDMI 1.4 standard.

HDR has plenty of promise, but the road ahead isn't clear yet. The biggest problems aren't technical roadblocks but competing, partially incompatible standards that threaten to detour early adopters into expensive dead ends. Two main standards for HDR currently exist: the proprietary Dolby Vision and the open standard HDR-10.

PC manufacturers are racing to join in on the HDR phenomenon, but you don't have to wait for them to try it out. Hardware HDR has already arrived for consumers in the high-end television market. This is also the best way to see the difference HDR makes in action, as a small but growing library of HDR demos, films and television make side-by-side comparison easy.

One place where PCs are already prepared for HDR is the graphics card market. While monitors lag behind their TV counterparts in HDR implementation, mid- and high-end GPUs have been ready for the revolution for almost a year now, thanks to the healthy rivalry between Nvidia and AMD.

The trickier question is what all of this means for PC gamers. While some new games will come out of the box with HDR in mind, older software won't support the wider colour and contrast capabilities without patching. Those older games may play normally on HDR-equipped systems, but you won't see any benefits without some fresh code added to the mix.

This means popular games may, in the future, get studio remasters or patches adding HDR support, and the mod community is likely to step in where manufacturers won't with older classics. Unlike the simulated or averaged HDR found in early games or used in photography, hardware HDR packs a visceral visual punch that's already catching on in the entertainment industry.

Until HDR patches and games start arriving, however, it's going to be limited to Blu-ray and streaming content, along with the indignity of seeing consoles get access to enhanced HDR visuals first. ■

technotes

» GEAR WE WANT

STAR WARS BATTLE QUADS

Quadcopters from a galaxy far, far away.
PROPELSW.COM | PREORDER FROM US\$200

Okay, this new Millennium Falcon from won't help you send Darth Vader spinning off into the depths of space, but it can fly at a speed of 80km per hour (the Speeder Bike, X-wing and TIE Fighter versions will be a little slower, with an average speed of 55km per hour), do 360-degree tricks and have laser fights with up to 24 other pilots. Yep, with other pilots. Each of these drones is a quadcopter with translucent plastics used to hide the propellers fixed beneath each vehicle, and uses on-board sensors for an aerial game of laser tag. Pre-order now to feel the Force in the fall.



DLODLO V1

Comfortable virtual reality glasses.
DLODLO.COM | ~US\$599

VR glasses that are light and comfortable to wear... Can it be true? Yes, these virtual reality glasses are, uh, real. Looking like a pair of futuristic sunglasses, the carbon fiber Dlodlo V1 set weighs a mere 87.8 grams and is just 15mm thick. (The Oculus Rift headset weighs over 450 grams and is over 200mm in depth.) You'd think the focus on weight reduction might have an impact on features, but the bionic optics give a 105-degree field of vision, a 2,400 x 1,200 resolution display, a 90Hz refresh rate, and the glasses even boast touch control. You do get a separate pack to power the glasses, but at least you don't have to wear it on your head.

LEIF

Credit card-sized tracking device.
LEIFDOES.COM | TBC PRICE

It's all too easy to leave your wallet at the gym, or on the table in a restaurant. The size of a regular loyalty card, the LEIF tracking device slots into any wallet and works with the GPS on your phone to map out its location, so you never lose it again. The range is 9-12m, with the distance tracker counting down as you get near. If you're out of range, LEIF will display where the wallet was last 'seen' on a map. The app even works with Google Maps to pull contact info, so you can call the store or restaurant to say you've left your wallet behind. A charging pad is included, but battery life depends on how often you lose your wallet...





FLOATING CLOUD

A Bluetooth speaker Zeus would approve of.
WWW.CREALEV.COM/MAKING-WEATHER | TBC PRICE

The Floating Cloud is the product of an ongoing collaboration between Crealev and Richard Clarkson Studio. The Cloud is a Bluetooth speaker that levitates about 5cm above its sleek oval base, utilising magnetic forces. The base itself is wooden with a mirror surface, so the underside of the Cloud can be admired. During use, the base is plugged in, with the Cloud remaining wireless. When music is played, the Cloud slowly rotates and bobs slightly, but the best part about the Cloud is its internal LEDs that reflect the beats of the song being played like a lightning storm. It's cool, despite looking a bit like mashed potato. CS

SPLASHLIGHT

Watery fun you can see at night.
 US\$24.95 | WWW.BIOTOY.COM/EN

The SplashLight is the perfect water pistol for night-time aqua fights, using the power of natural bioluminescence – the chemical reaction between proteins, light-emitting molecules and oxygen. This toy requires only that you fill it up with regular water from the tap, then pop in the ReLume tablets (the bioluminescent fuel) in a separate chamber. The rest of the magic happens inside, turning H₂O into glowing liquid that you can then shoot at your opponents. It's apparently safe, easy to wash out of your clothes, has a range of 3.6m and, once loaded, the glow can last up to four hours. CS



GOOGLE HOME

OK Google...
MADEBY.GOOGLE.COM/HOME | US\$129

Google Home is an always-listening voice-activated speaker powered by Google Assistant. Simply command your music, radio or podcasts to play and, if in range, the Home will hear and comply. It's compatible with third-party apps like Spotify, Pandora and TuneIn, as well as its own Google Play Music, as well as being able to connect to your Chromecast. Ask your Home questions, such as traffic or weather conditions before you leave for work or link it with your Hue globes to verbally turn off the lights or change the mood. You can also set alarms and timers, as well as linking it with your calendar to give you updates and reminders. However, as we were going to print, we were still waiting for confirmation of an Australian release. CS ■



LAUNCH
FROM £1,999 • WWW.DELL.COM.UK

Dell XPS 13 (2016)

The best business ultrabook around

Much praise has been heaped on Dell's current XPS 13 laptop since it landed back in early 2015, with many lauding it (as included) as the best Windows ultraportable around. It was a little under a year since Dell last refreshed the XPS 13, and with this late 2016 model, it's taken the sensible (if slightly boring) route of not messing with what already works – in short, we've got updated internals and a new colour option, but that's about it.

It's a bit of an old-descript refresh then – and, in fact, from the outside, it looks pretty much identical to last year's model, barring the fact that the gold-coloured chassis has now been swapped for rose gold. Presumably because, hey, everyone else is doing it, so why not? Thankfully, Dell's idea of rose is actually a slightly reddish-orange hue that's closer to a

bronze than a pink – even many men should be able to use one of these without feeling too emasculated. What is worth getting mildly excited about is what's under the hood – specifically Intel's new 7th-gen Core i5 processors (aka Kaby Lake). These new chips have landed first on mobile, with desktop equivalents set to be launched around the time this issue of APC comes out. Intel's new chip has very little fuss about them and, indeed, they don't offer much of a performance boost over their 6th-gen predecessors. What we did note, however, was a big jump in battery life on the Core i7 model: we tested for this review and saw a pretty big gap between the runtime

LAUNCH PERFORMANCE

Model	Cinebench R15	PCMark 10	Geekbench 4
Dell XPS 13 (2016)	2040	2540	1540
HP Spectre x360	1800	2400	1400
Lenovo Yoga 920	1700	2300	1300
ASUS ZenBook UX301	1600	2200	1200
Microsoft Surface Book	1500	2100	1100

LAUNCH PRICE

Model	Price (£)
Dell XPS 13 (2016)	1999
HP Spectre x360	2199
Lenovo Yoga 920	2099
ASUS ZenBook UX301	1999
Microsoft Surface Book	2299

LAUNCH WEIGHT

Model	Weight (kg)
Dell XPS 13 (2016)	1.37
HP Spectre x360	1.40
Lenovo Yoga 920	1.35
ASUS ZenBook UX301	1.30
Microsoft Surface Book	1.70

LAUNCH BATTERY LIFE

Model	Battery Life (hrs)
Dell XPS 13 (2016)	22
HP Spectre x360	20
Lenovo Yoga 920	21
ASUS ZenBook UX301	19
Microsoft Surface Book	15

When we're getting mildly excited about what's what's under the hood – specifically Intel's new 7th-gen Core i5 processors.

of the Core i5 and Core i7 models of the XPS 13 – with the latter offering only about 430Wh to the i5's 530Wh. Some of that undoubtedly came down to a difference in display too, with the i5 model sporting a 13.3-inch 1080p IPS screen vs the i7's not quite 4K screen at 13.00 x 1800 pixels.

On the new Core i7 model, under lighter workloads, that two-hour battery shortfall has been completely eliminated – despite still having that same super high res display. You can surf the web or watch movies for nearly 7 hours, so choosing the faster model doesn't come with the runtime trade-off that it used to.

Otherwise this is still a top-notch ultrabook, with a fantastic keyboard and trackpad, near 1.3kg weight and high build quality. Oh, and the other bit of good news is that the XPS 13 still comes in silver – so, fella, if rose gold isn't your thing, you can pick one up without feeling like you've sacrificed any quality for masculinity.

Dr. Gerwyn

Verdict

Features ★★★★★
Performance ★★★★★
Value ★★★★★

More power? Design, less battery
 Having a more powerful processor is a handy thing, but it's also important to be aware of the trade-off between power and battery life.

★★★★★

www.apcmag.com 23

Find out all about APC's editorial policies, test practices, how to read the benchmark results and more.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And like you, APC's journalists want to know what's good in tech — no matter what platform it resides on.

As a matter of policy, reviews published in APC are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an APC reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

We use both tables and graphs for displaying results; the latter are our preference due to their ease-of-readability, but tables are more compact, so we use these in cases where thoroughness is preferred.

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Apple sure does piece together some pretty systems.

Unfortunately, all the chips are still soldered to the PCB.

12-inch Apple MacBook (2016)

The 2016 Retina MacBook achieves the worst score iFixit can award.

MAJOR TECH SPECS

- 12-inch, 2,304 x 1,440-pixel (226ppi) IPS Retina Display
- 1.1GHz dual-core Intel Core m3 processor (configurable up to 1.3GHz dual-core Intel Core m7)
- 8GB of 1,866MHz LPDDR3 RAM
- 256GB or 512GB PCIe-based flash storage
- Intel HD Graphics 515
- 802.11a/b/g/n/ac Wi-Fi wireless networking and Bluetooth 4.0
- Single USB-C port and 3.5mm headphone jack

KEY FINDINGS

- If it weren't for the rose gold finish, we'd be hard-pressed to distinguish this year's Retina MacBook from yesteryear's. The exteriors look identical.
- The pesky tri-wing screw we saw last year grew another wing — now it's a repair-friendly Phillips. Thankfully, all the other internal screws are still Phillips and Torx screws.
- At the other end of the MacBook, the USB-C hardware has also changed. The cable is now perma-fixed to the USB board, condensing the two

components into a single unit. Also, the silicon is new and has moved from the cable itself to the USB board. This new USB and cable arrangement is one thing that's not compatible with previous Retina MacBooks.

- The battery's form factor seems identical to the multi-lobed cell in the 2015 MacBook, yet somehow Apple has managed to squeeze in a 4% capacity increase from last year's model. Apple claims the new 7.56V, 41.41Wh Lithium-ion power source should provide 11 hours of iTunes movie playback. We're guessing this capacity increase is due to improved battery chemistry (though it's also possible that Apple's engineers have shaved away just enough material from the lower case to allow for a thicker battery). Unfortunately, they

did not squeeze in any of those nifty adhesive pull tabs we've seen in Apple's iDevices. Regardless, our tests indicate this beefier battery is compatible with last year's MacBook. Which is nice!

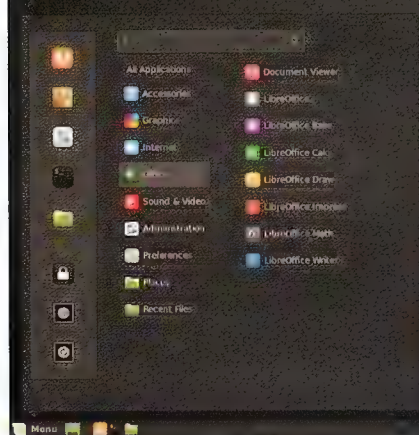
- **Repairability Score:** 1 out of 10 (10 is the easiest to repair). Those pesky tri-wing screws are gone, replaced by lovely standard Phillips screws — but tamper-evident hinge screws make you feel like a hoodlum for repairing your own machine. The processor, RAM, and flash memory are still soldered to the logic board. The battery assembly remains entirely and very solidly glued to the lower case. The Retina display is still a fused unit with no separate, protective glass. If the display needs replacing, it'll cost a pretty penny. ■

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

technotes

» OPINIONS



"I find that Linux leaves a smaller footprint on the hard drive, the apps are smaller, the updates are smaller and seldom require a restart."

ANOTHER VOTE FOR LINUX

I have been dual booting Linux Mint and Windows (Vista, Windows 7 and now Windows 10) on a dual-core Pentium T2400 Notebook for many years now.

I find that Linux leaves a smaller footprint on the hard drive, the apps are smaller, the updates are smaller and seldom require a restart. The GUI is just as easy to use as the Windows GUI. Just as in Windows, most functions can be done using the GUI and you seldom have to use the command Prompt (Terminal). There are equivalent Linux apps for doing most everyday tasks, which are just as good as Windows apps. There is even an emulator (DOSBox) that runs DOS programs, including games.

Some of my peripherals don't work or work with reduced functionality and some streaming services don't work (such as Stan), but the main reason I haven't switched to Linux is that games designed for Windows don't work on Linux.

Because I have a Windows 10 32-bit operating system, many Windows 95/98 games still run. Is it possible to

use Wine to run these games under Linux? If so could you do an article on how to do this?

Carl Francis

GETTING TO GRIPS WITH LINUX

Linux is something you need to understand. It works a lot different to Windows: it's all about choice. When you choose a distro, you're choosing a family to belong to – be that Debian, Red Hat, Puppy, Ubuntu or something else.

I've found it easy to use and install, it runs for years and is almost virus-proof (for now). Plus it's free and it can make old computers feel new again. I was given an old HP laptop from the rubbish heap – I cleaned it up and put in a hard drive from another dumper with a cracked screen, then installed Linux Mint and downloaded a heap of apps. It runs like new or better – it's now my favourite.

I'm a fan of the little Aussie distro, Puppy Linux. I use the Slacko Puppy distro and it's a marvel. You can run it from a disc, install it to a USB or use frugal install (that's a folder on Windows, that's basically a save file

or mini hard drive). Plus if you keep a copy of this save file, you have an almost instant rebuild, in case something goes wrong.

My Slacko has Wine and lots of Windows apps, plus VirtualBox running Windows 2000 just for pinball. I have no need for Windows 10. Throw in an Android smartphone and all my device needs are taken care of.

That said, I wish they would bring out an Ubuntu laptop – my money is waiting to be spent. First thing I'd do would to wipe it clean and put on Mint and Slacko.

I have the Linux bug and it's wonderful!

Allan Clark

CORRECTION

Due to an oversight at the time of production, the incorrect price for Corel Painter was listed in last month's APC (issue 434, November 2016, page 38). The correct price is \$429. We regret the error and apologise for any inconvenience caused. ■

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Come on, have your say!

We want to hear what you think. Add to these discussions or email your views (in fewer than 250 words) to apcmag@futurenet.com. All correspondence becomes the property of APC and is subject to editing. Letters must include full name, street address, suburb, state and phone number to be considered for print publication. Address and phone details will not be published.



Can you trust the 'wisdom of the crowd'?

When it comes to online community reviews, digital storefronts need to clamp down on dodgy reviewers, writes Shaun Prescott.

Who needs professional reviewers when there are masses of opinionated people champing at the bit to be heard? For those disenchanted with the traditional media, scrolling through the endless reviews found on Steam or Amazon is preferable to reading a single, authoritative review – and aggregators providing an emphatic, overall score based on these reviews are very popular, too.

But not all is well in the world of opinionated consumers: those countless reviews, sometimes funny, often helpful (usually poorly punctuated) have some bad eggs among them. Based on some amendments Valve made to Steam's review system in September, the problem is obvious: it's far too easy to skew average scores.

In a dramatic move, Steam's overall score assigned to each title no longer takes into account key activations; ie, the method often used by reviewers and crowdfunders to access games on the platform. That means game developers and publishers can no longer count on boosting their average score by paying for reviews, or simply

incentivising good reviews via free access to the game.

It sounds pedantic, but where Steam is concerned, it's very important: not only do Steam average scores mean a lot to the platform's heavy users, but they also determine how visible the game is on the shopfront – not to mention that some studios receive bonuses based on their review rankings. When Valve introduced the change, many reviews changed score in both favourable and unfavourable directions, and some saw very dramatic changes.

It's not just Steam: a recent study by Review Meta found that incentivised reviews – ie, those based on product or services provided free to the reviewer for testing purposes – are more likely to be higher than those that aren't incentivised. "We found that on average, reviewers who have written at least one incentivised review give an average of 4.56 stars, while reviewers who have never written any incentivised reviews give an average of 4.27 stars," the study found.

Whereas journalists and professional reviewers usually (but not always) do

their best to strive for impartiality, enthusiasts might not. That doesn't mean they're bad: it simply means that they haven't been trained in, or have any awareness of, media ethics. They're enthusiasts, not professionals, but when there's virtually no way to distinguish enthusiasts from professionals, that's when things become complicated for the person trying to separate reliable impressions from the guy who got a free Bluetooth Clothes Iron and wants to make sure the loot keeps coming.

It's not just a problem for consumers, because the shopfronts will themselves suffer if better checks and balances aren't put in place. While Amazon is unlikely to tumble under the immense pressure of crappy reviewers, the usability of the site will likely plummet if not-so-great products are given precedence over those that shine. Valve is making some fairly dramatic steps to curb the exploitation of its ratings system, and while this has annoyed a lot of smaller developers, it's a move that needs to be made – and it's a problem that will likely keep rearing its head as newer systems show their weaknesses. ■

END USER

Share your stories!

If you have an interesting story about technology users, their experiences and the issues that affect us all (whether funny or serious), email us at apcmag@futurenet.com. All correspondence becomes the property of APC and is subject to editing. Letters must include writer's full name, street address, suburb, state and phone number to be considered for print publication. Address and phone details will not be published.

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ASUS ZenBook 3

Has ASUS's search for incredible uncovered the sublime?

We've had our eye on the sleek ZenBook 3 since ASUS first showed it off at Computex back in May. The elegantly coloured rose gold or royal blue chassis is honed from premium-grade aluminium to a 11.9mm profile. Yet it isn't just the body that's thin – the display's 7.6mm bezels marry a well-proportioned screen border to deliver a class-leading 82% screen-to-body ratio.

It might only have a 12.5-inch 1080p IPS LCD display with sRGB colour, but ASUS has covered it in Corning Gorilla Glass 4 and boosted the screen's 1,000:1 contrast ratio using its Tru2Life image processing engine which makes images and videos look clearer and richer than any other screen we've seen with these specs. Hidden neatly above the keyboard and underneath the trackpad are two sets of discrete ASUS SonicMaster Premium speakers tuned by

the audio masters at Harman Kardon. The audio volume and quality from such tiny speakers is surprising. Not only is it louder than most laptops we test, it's also extremely good quality, producing full bassy lows and crisp highs.

Non-Apple laptops have a known blindspot when it comes to trackpads, and though we've seen a few that get close, the ZenBook 3 is the first we like equally as much as Apple models. The 3's trackpad even adds in a fingerprint sensor. Add to this an exceptionally designed keyboard that offers standard 19.8mm key spacing and an impressive 0.8mm key travel distance and you end up with a compact keyboard and trackpad setup that doesn't feel like a compromise to type or swipe on.

At present, it's only possible to get the Intel Core i7-7500U CPU model in Australia, which is paired with either Windows 10 Home or Pro, an Intel HD

Graphics 620 GPU, 8GB of 2,133MHz DDR3 memory and a 512GB SATA3 M.2 SSD. For this 'thin and light' class, that spec sheet is impressive but when you weigh-up that you can get a 1440p MacBook with the same size hard drive for \$250 less, we wondered if the UX390UA achieves the performance to command such a price tag.

Despite ASUS's custom-designed 3mm-thick fan to help cool that Core i7 processor, not everything runs as smoothly as it should. When it comes to CPU-heavy tasks like web browsing, video transcoding and general office applications, the 7500U holds up, netting best-in-class scores on PCMark's Work and Home tests. However, its GPU scores are suspiciously low. Across all of 3DMark's graphics tests, it did worse than ASUS's \$1,099, Core M-powered UX305FA from last year and, moreover, seemed to be capped at around half the performance of the almost

identically specced) Dell XPS 13, opposite.

A middling 40Wh battery combined with a powerful CPU means that battery life was a bit less than we'd hoped, lasting only 2 hours and 40 minutes in PCMark's Home test and around 5 hours during 1080p media playback at 50% brightness.

That said, as long as you don't plan to do any gaming on it, there's really no glaring speed problems with the ZenBook. Considering it comes in at about the same price as a 512GB Core m7 MacBook, it's fairly-priced for a top shelf ultrabook.

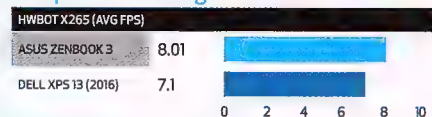
■ Joel Burgess

LABS BENCHMARK RESULTS

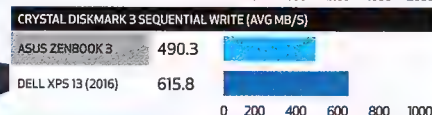
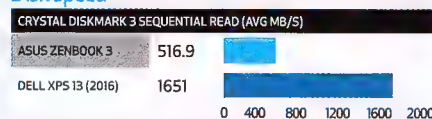
General performance



1080p media encoding



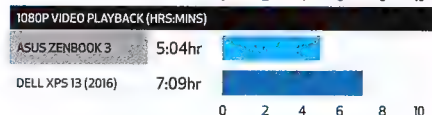
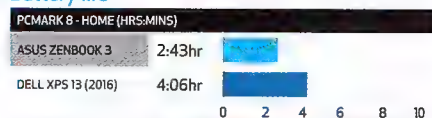
Disk speed



Gaming performance



Battery life



Verdict

Features ★★★★★
Performance ★★★★★
Value ★★★★★

Compact, well equipped for demanding working conditions and offers the best all-in-one ultraportable media setup.





LAPTOP

FROM \$1,999 | WWW.DELL.COM.AU

Dell XPS 13 (2016)

The best business ultrabook around, now available in pink.

Much praise has been heaped on Dell's current XPS 13 laptop since it landed back in early 2015, with many lauding it (us included) as the best Windows ultraportable around. It's been a little under a year since Dell last refreshed the XPS 13, and with this 'late 2016' model, it's taken the sensible (if slightly boring) route of not messing with what ain't broke – in short, we've got updated internals and a new colour option, but that's about it.

It's a bit of a non-descript refresh then – and, in fact, from the outside, it looks pretty much identical as last year's model, barring the fact that the gold-coloured chassis has now been swapped for rose gold... presumably because, hey, everyone else is doing it, so why not? Thankfully, Dell's idea of 'rose' is actually a very subdued reddish-orange hue that's closer to a

bronze than a pink – even manly men should be able to use one of these without feeling too emasculated.

What is worth getting mildly excited about is what's under the hood – specifically Intel's new 7th-gen Core i processors (aka Kaby Lake). These new chips have landed first on mobile, with desktop equivalents set to be launched around the time this issue of APC comes out. Intel's made very little fuss about these and, indeed, they don't offer much of a performance boost over their 6th-gen predecessors. What we did note, however, was a big jump in battery life on the Core i7 model we tested for this review.

Last year, we saw a pretty big gap between the runtime

of the Core i5 and Core i7 models of the XPS 13 – with the latter offering only about 4:30hr to the i5's 6:30hr. Some of that undoubtedly came down to a difference in displays, too, with the i5 model sporting a 13.3-inch 1080p IPS screen vs the i7's not-quite-4K screen at 3,800 x 1,800 pixels.

On the new Core i7 model, under lighter workloads, that two-hour battery shortfall has been completely eliminated – despite still having that same super high-res display. You can surf the web or watch movies for nearly 7 hours, so choosing the faster model doesn't come with the runtime trade-off that it used to.

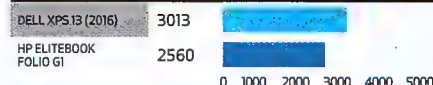
Otherwise this is still a top-notch ultrabook, with a fantastic keyboard and trackpad, neat 1.3kg weight and tough build quality. Oh, and the other bit of good news is that the chassis still comes in silver – so, fellas, if rose gold isn't your thing, you can pick one up without feeling like you've sacrificed any of your masculinity.

■ Dan Gardiner

LABS BENCHMARK RESULTS

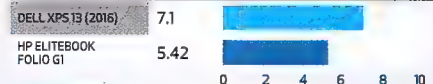
General performance

PCMARK 8 - HOME (SCORE)



1080p media encoding

HWBOT X265 (AVG FPS)

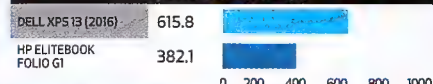


Disk speed

CRYSTAL DISKMARK 3 SEQUENTIAL READ (AVG MB/S)

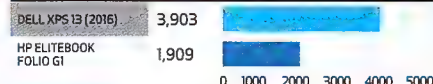


CRYSTAL DISKMARK 3 SEQUENTIAL WRITE (AVG MB/S)



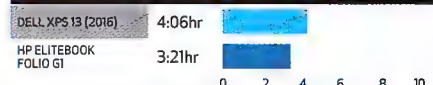
Gaming performance

3DMARK SKY DIVER (SCORE)

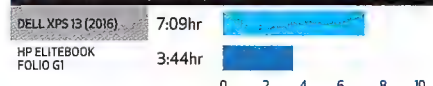


Battery life

PCMARK 8 - HOME (HRS:MIN)



1080P VIDEO PLAYBACK (HRS:MIN)



"What is worth getting mildly excited about is what's under the hood — specifically Intel's new 7th-gen Core i processors."

Verdict

Features ★★★★★
Performance ★★★★★
Value ★★★★★

Near-perfect design, new hardware brings a welcome improvement to battery life to the top end-models.



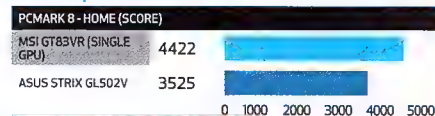


GAMING LAPTOP

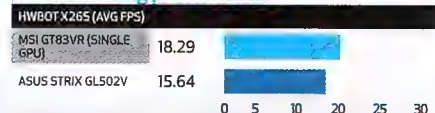
\$7,499 | AU.MSI.COM

LABS BENCHMARK RESULTS

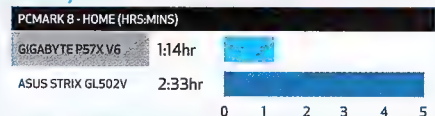
General performance



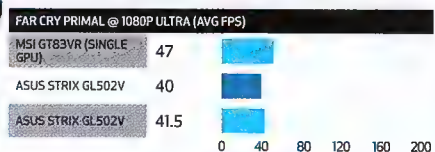
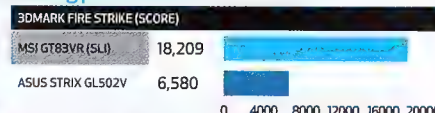
Media encoding performance



Battery life



Gaming performance



MSI GT83VR 6RF Titan SLI

This pricey Titan earns its stripes in specs, but how does it perform in the real world?

We'd expect nothing less than a full desktop-grade Nvidia GeForce GTX 1080 GPU for MSI's mothership gaming laptop, but this unit actually has two of them, which can be used in unison through Nvidia's Scalable Link Interface (SLI) tech.

The GT83VR has also been equipped with a quad-core, HyperThreaded Intel Core i7-6920HQ CPU, plus an astounding 64GB of DDR4 RAM. Add to this two NVMe M.2 SSDs in a striped RAID 0 config for 512GB of super-speedy storage, clocking in at the fast sequential read and write speeds of 3,114MB/s and 2,556MB/s, respectively. The caveat is that you need two enormous power bricks that have to cross streams in order to deliver the juice.

Interestingly, it also has a mechanical keyboard (with Cherry MX Brown switches) and a trackpad that doubles as a digital numpad.

The front edge is only fractionally bigger than you'd expect from a normal gaming laptop, at 4.2cm, but the chassis thickens out to 6.9cm as you get closer to the screen. All this adds up to a 5.5kg package that seems impressively lightweight for what it contains.

It's a bit of an engineering feat to get two desktop GPUs to fit into a laptop chassis, but to keep them cool, you'll either need an external water cooling system or enough fans to start a small wind farm. Since the GT83VR opted for the latter, you can hear it from over 5m away when the fans are running full tilt. Fortunately, they rarely actually hit top speed – even when gaming.

This comes at the cost of performance consistency, as the unit regularly failed 3DMark's new consistency stress test, with scores around the 96% mark (to be fair, 97% is a pass). You can manually boost the fans to keep the GPU and CPU temperatures stable (and

under 83°C) which does rectify this, but you'll need an impressive set of noise-cancelling headphones to block out the whooshing noise this creates.

So how does SLI hold up on the go? As on desktop, it's a bit of a mixed bag. Many of the games in our test suite actually haven't been optimised for SLI setups. This means that, despite wiping the floor with synthetic benchmarks like 3DMark – where it nabbed a mind-numbing score of 13,921 in the Fire Strike Extreme test – for lots of real-world games, that second GPU offers minimal speed improvements only (we saw an average of 7% across *Batman: Arkham Knight*, *BioShock Infinite* and *Metro Last Light*) and/or requires you to troubleshoot settings to get them to work.

In some instances, SLI reduced performance. As a case in point, running the demanding *Far Cry Primal* at 1080p Ultra settings netted 47 and 33, average and

minimum frames rates when using a single GTX 1080 GPU. But that dropped to 40 and 24fps, respectively, when both GPUs were utilised. It's hard not to feel that, despite being over a decade old, SLI is still not really ready for mainstream use.

One puzzling thing: considering you're being asked to fork out \$7,499 for a system that can reliably run intensive games when using 4K ultra settings, it seems bizarre that a 4K screen was not included – but to be fair, this could be because 18.4-inch laptop displays don't come in this resolution yet. **Joel Burgess**

Verdict

Features ★★★★★
Performance ★★★★★
Value ★★★★★

Packs some of the best mobile hardware money can buy, but performance often hinges on SLI driver optimisation.





HELIUM HARD DRIVE

\$1,049 | WWW.HGST.COM

LABS BENCHMARK RESULTS

Our standard test bench consists of an Intel Core i7-6700K, MSI Z170A Gaming M7, 16GB Crucial Ballistix Elite DDR4-2666, and a GeForce GTX 1080.

AS SSD SEQUENTIAL READ (MB/S)

HITACHI HE10 10TB	231	
HITACHI HUA7220 2TB	115	

AS SSD SEQUENTIAL WRITE (MB/S)

HITACHI HE10 10TB	190	
HITACHI HUA7220 2TB	105	

AS SSD 4K RANDOM READ (MB/S)

HITACHI HE10 10TB	0.63	
HITACHI HUA7220 2TB	0.61	

AS SSD 4K RANDOM WRITE (MB/S)

HITACHI HE10 10TB	2.8	
HITACHI HUA7220 2TB	1.3	

Hitachi UltraStar He10 10TB

Hitachi crams the population of China into a small family car. Kinda...

In this brave new solid-state era, it's easy to forget that magnetic drives still do the heavy lifting when it comes to mass storage. SSD prices may have tumbled, but multiple terabytes of solid-state storage remains super expensive.

It's also easy to overlook the remarkable technical innovation that underpins the relentless increase in data density offered by the latest magnetic drives. To get an idea of the progress that's been achieved over recent decades, here's a nice analogy we just shamelessly stole off the internet. If cars had improved their cabin space since the early 1980s at the same rate that hard drives have increased data capacity, you'd be able to cram the entire population of China into a small family sedan. Crazy.

For more tangible proof of that progress, however, look no further than Hitachi's latest multi-platter masterwork, the Ultrastar He10. As implied by the 'He'

branding, one of the drive's defining features is the use of helium inside a hermetically sealed enclosure. This is Hitachi's third-gen helium drive.

Using helium bestows a number of advantages, the most obvious of which is gaseous density just one-seventh that of air. That makes for less drag acting on hard drive platters. With less drag, the motor needs less power and the fluid flow forces buffeting the platters and arms are reduced. Every little bit helps when you're trying to cram more data onto a magnetic platter than ever before.

The He10's use of Shingled Magnetic Recording (SMR) technology is new. The shizzle here, in layman's terms, involves the layering or overlapping of the recording tracks. As the name suggest, think of the tracks as arranged like an overlapping shingled roof rather than tiles arranged edge-to-edge, thus allowing more tracks in the same surface area and, in turn,

greater data density. How much greater? Say hello to 10TB of space, baby.

As is often the case with new tech, SMR has been problematic from a performance perspective. But with claimed sequential performance numbers in excess of 200MB/s from this 7,200rpm drive, that's something Hitachi seems to have solved. Our benchmark results paint a similar picture. In both ATTO Disk Benchmark and CrystalDiskMark, the He10 cranks out around 250MB/s for both sequential reads and writes.

At 3 minutes, 26 seconds, it's competitive with a SATA SSD in our real-world file compression test. The 4 minutes, 24 seconds it requires to complete the 30GB internal file copy metric is less impressive. But like all magnetic drives, the real downer compared to solid-state storage is 4K random access performance.

The He10, knocks out reasonable 4K numbers for a magnetic drive, such as

5.97MB/s writes in CrystalDiskMark. That's probably due, at least in part, to the new Media Cache feature on the He series. Media Cache reserves cylinders to use as instant write buffers. This reduces head movement, which makes for shorter average seek times.

It's still a tiny fraction of the +100MB/s a half decent SSD would achieve in the same benchmark. SSDs remain by far the better bet for performance. But if you want a lot of storage in a single drive and can handle the hefty price, this is a great option if you need lots of gigs. ■ Jeremy Laird

Verdict

Features	★★★★★
Performance	★★★★★
Value	★★★☆☆

Massive storage capacity, excellent performance for a magnetic drive, mediocre random speeds vs SSD.



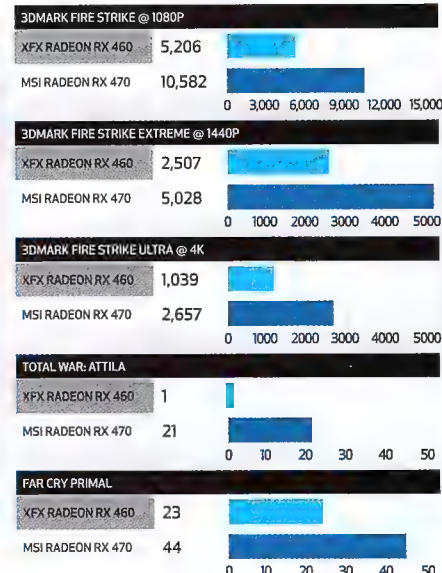


GRAPHICS CARD

\$189 | WWW.XFX.COM

LABS BENCHMARK RESULTS

Our test bed consists of a Core i7-6700K, with 16GB of Kingston Savage DDR4 @ 2,400MT/s on an MSI Z170A Gaming M7 motherboard.



XFX Radeon RX 460

An esports card, but is it worth it?

AMD has had an incredible run since the launch of Polaris. Indeed, the RX 480 has scooped up a number of awards. The GTX 1080 may be the king of the frame rates, but it's the dollars per fps that cinch the deal for us. So how far can you push the value bracket before things go asunder?

AMD's Radeon RX 460 is a low-end budget card. Aimed at esports gaming, particularly *League of Legends* and *DOTA II*, it's not a great pixel-destroyer, nor is it capable of channeling AAA titles at acceptable frame rates. That said, that's how we do most of our testing, so to ignore it would be ludicrous, regardless of how much AMD moans at us about it.

So for a meager \$169, you can grab a sizable chunk of Polaris 11. With currently only the RX 460 in this tiny 14nm graphics family, this variant comes with three billion transistors, 896 shader units, and 2GB of

GDDR5 on a 128-bit bus, allowing for a total memory bandwidth of 112GB/s. That's quite a drop from Polaris 10. In fact, it's over 2 billion transistors and 1,152 shader units fewer than its closest neighbor, the RX 470, which is currently available from about \$289. That's a \$120 difference for more than double the performance of the RX 460.

And, boy, does it show. At 1080p, the RX 460 hardly competes in our benchmark suite, scoring a paltry average frame rate of 14 in *Attila*, 12 in *Rise of the Tomb Raider*, and 30 in *Far Cry Primal*, a game well known for its solid optimisation in our benchmarks.

Yes, cynics will be saying, "Well, it's not built for that," and we have to agree – no, it's not. Its design ethos is entirely centred around esports. So if you're an esports gamer, you're going to want this, right? Thing is, you don't just play one game for eternity. Perhaps you're

not interested in grinding out ladder today, but instead want to jump into an RPG, or the latest *Assassin's Creed* or *Project Cars*? Well, if you chose this card, you couldn't, not without dropping the graphical settings quite considerably.

The pros, who play *CS:GO*, *LoL*, *DOTA II* or *Overwatch* every day, already have top-end cards, because they want the highest frame rates, and the quickest refreshes they can get. And more casual esports gamers aren't going to be dedicated enough to not play other games on the side as well.

We keep seeing this trend – products being designed with such a niche market in mind that they fail to excel at what they were designed to do. Intel's latest NUC, for example, had the whole gaming nomenclature down to a T, yet struggled with gaming. These are products that are still

very impressive, but the marketing divisions seem content to stick labels on them that simply don't fit.

For what it's worth, for its overall die size, the GPU at the heart of the RX 460 is an incredibly strong performer. But for the price, it's way off. When you have the likes of the RX 470 costing around \$110 more – or the price of a couple of games – it offers much better value and longevity.

As it stands, the 460 is a budget option with a price-to-performance efficiency comparable to a Fury X or GTX 1070 – but without the top-level performance.

■ Zak Storey

Verdict

Features ★★★★★
Performance ★★★★★
Value ★★★★★

Low power, small form factor and good for MOBAs, but poor value and with limited gaming potential.





PC CASE

\$150 | WWW.CORSAIR.COM

Corsair Carbide Air 740

Reworking internal perfection.

The design of this cuboid case is unique way of keeping a small footprint on an otherwise cumbersome full tower.

Corsair's Carbide Air 740 is a well-needed upgrade on the ageing 540. Gone are the dual 5.25-inch front drive bays, the floor mounted 3.5-inch hard drive mounts, and the simple refined design. In its place is a sleeker, tuned matte chassis, designed around the digital age.

The cleaner internal layout allows for far superior cooling options, yet with still enough hard drive space to keep even the most enthusiastic RAID 5 supporter happy. It looks stunning, more so in person than any box art or stock photography could ever reveal.

Speaking of cooling, you're spoilt for choice. In the main compartment, you can fit a 360mm radiator in the front, a 280mm rad in the roof and in the floor, and a 140mm

rad in the rear, or of course their corresponding fan sizes. The secondary chamber is a little less forgiving, with the potential to mount two 80mm fans in the rear, and there's a sufficient filtered intake grate for your power supply to suck air through as well. The main compartment is most intriguing. It actually gives you the option to run a more thermally attuned cooling orientation.

The 2.5-inch bays in the rear compartment were a tricky to remove, resulting in us snapping two of the retaining pins off one of the cages. Bad design? We think so; however, it's certainly not enough to detract from the positives.

■ Zak Storey

Verdict

New internal layout, vast cooling support, stylish, slightly larger than most. Some design flaws.



SMARTPHONE

\$280 | WWW.MOTOROLA.COM.AU

✓✓✓
apc
RECOMMENDS

Motorola Moto G4 Play

A budget smartphone proving that you don't always have to pay to play.

The new G4 Play is a bit thinner, lighter and sleeker than what we're used to seeing from Moto. In fact, we'd go so far as to call this the best-looking budget phone the company has produced and it's one whose textured back and 5-inch size make it comfy to hold, too. At the time of testing, the G4 Play was running Motorola's largely-untouched version of Android 6.0.1 – so it's nice and speedy without any bloatware. Motorola has said it'll get the Nougat upgrade down the track.

Inside, there's an entry-level Qualcomm CPU (the 1.2GHz Snapdragon 410 CPU – effectively the 'Core i3' of the Snapdragon range) plus 2GB of RAM, an Adreno 306 GPU, 2,800mAh battery and 16GB of onboard storage. Generally, that hardware handles all the basics fine – web surfing, email, Facebook and the like were smooth and lag-free. The display is only 720p, and does struggle with visibility

in bright sunlight, but that's par for the course at this price. The one area where the hardware does fall over is in gaming – somewhat ironic, considering the 'Play' name. In a word, it's pretty dire, managing about 10% the speed of what you'll get on a flagship device from Samsung. It'll hold up for Candy Crush... just don't expect to be able to do real-time 3D VR experiences.

If you can handle that, there are other features to like, such as a microSD slot for expanding your storage and a removable battery. In short, if you don't have a lot to spend on a phone, this one still delivers almost everything you'll need in a fairly pleasing package.

■ Dan Gardiner

Verdict

There's lots to like in this budget Motorola offering for those not looking for a gaming device.





3D PRINTER

US\$4,199 PLUS SHIPPING | [FORMLABS.COM](http://formlabs.com)

Formlabs Form 2

Exceptional-quality 3D printing right from your desktop.

Formlabs is established as the leading stereolithography (SLA) 3D printer manufacturer. This kind of printer uses a resin instead of a filament, which hardens when it's exposed to ultraviolet light.

The main build platform of an SLA printer is suspended over a resin tank, so as the print is mapped out by the laser, the thing you're printing is built upside down and looks like it's being pulled (albeit very slowly) right out of the resin.

The resin comes in a specially shaped bottle that drops into the printer's base, and it automatically pours into the tank as the printer is primed before use. Commissioning takes about 20 minutes, and once started, it's best to wait with the printer just to check everything's in order. If you try to print on an uneven surface, the printer alerts you to level it using the small adjustable feet on the base.

"The Form 2 is designed for people in need of a high-end 3D print solution, and it's ideal if you need to make prototypes, small product runs or detailed quality models or jewellery designs."

When it comes to printing from your Mac, you have the choice of connecting the printer to your computer using USB, Ethernet or Wi-Fi. Setting up the latter from the small interface on the printer is quick and easy enough, and once done, you can send prints without the need to reconnect physically.

As with the vast majority of new printers, the Form 2 comes with its own software: PreForm. This handles the majority of the printer's settings and enables you to quickly select quality as well as the material type.

Upon importing a 3D model, the software will instantly detect if there are any issues with its integrity and then repair them automatically. We

found it did an incredible job of eliminating intersecting faces and repairing any that are missing without issue.

Once the print finishes, it can be removed from the build plate. Compared to a filament printer, the process of print removal is a little more involved and time consuming; the whole process from start to finish can take about 24 hours for the print to fully harden, but the end result is worth it. Print times are slower than with a filament printer, but only by about 10–20%, depending on the model.

The Form 2 is designed for people in need of a high-end 3D print solution, and it's ideal if you need to make prototypes, small product runs or detailed quality

models or jewellery designs. The process of producing a print is more time-consuming, messy and expensive than with a filament printer, yet the results are exceptional.

The Form 2 really does give you the best possible finish and quality you can get from a desktop 3D printer.

■ Ali Jennings

Verdict

Features ★★★★★
Performance ★★★★★
Value ★★★★★

At present, there's no other desktop 3D printer that comes close to the standard set by the Form 2.





The home of technology

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software

» APPS FOR ALL THE PLATFORMS



Windows SOFTWARE

MusicBee

Easy to use and feature-packed – easily the best free player around

FREE | [TINYURL.COM/APC435-MBEE](http://tinyurl.com/APC435-MBEE)



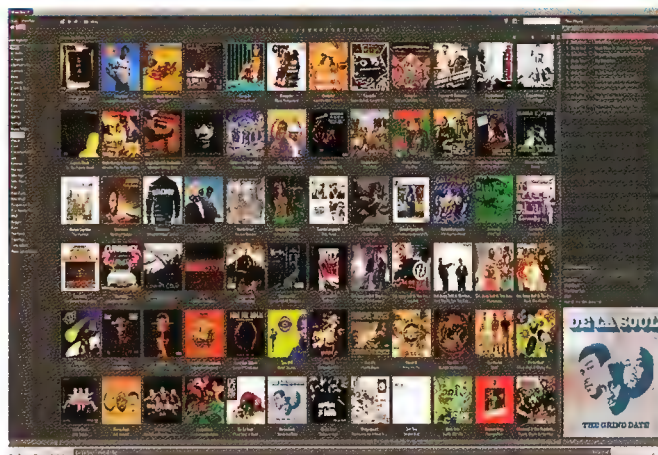
MusicBee is a music player created for serious music lovers and includes everything you need to manage and enjoy your collection, no matter how large (it's reportedly handled a library of over 500,000 tracks without a hiccup).

Switching to MusicBee is easy. The first time it runs, the app scans your PC for music and lets you import your files from Windows Media Player or iTunes. Tracks are catalogued, but aren't moved unless you've checked that option under Library Preferences so there'll be no surprises.

Once your songs are imported, tagging them is a piece of cake; hit Shift-Enter to open the tag editor and go to work. MusicBee's automatic tagging is superb, or you can update metadata yourself using industry-standard tags for each file format.

As in Windows Media Player, adding artwork is as simple as copying and pasting, and it isn't limited to the album cover – you can also add pictures of the artist, lead singer, band logo, and photos from live performances. These additional pictures are used throughout the player as navigation aids, and as visualizations while tracks are playing. MusicBee also searches for song lyrics to display as each track plays.

The player is designed to make the most of your PC's hardware, including top-end soundcards and surround-



sound setups, with upmixing for stereo sound. Continuous playback eliminates silences between tracks (ideal for Pink Floyd fans), and you can choose to add silences or fades, normalise volume, and experiment with the equalizer.

MusicBee is also great for streaming from internet radio stations and listening to podcasts, and supports both SoundCloud and Last.fm. You can even link it to VLC Media Player to stream video podcasts.

The player supports almost every audio format around and converting files is simplicity itself, with presets for different playback devices (though for MP3 encoding you'll need to download the LAME codec).

If all of that isn't enough, there's even an Android app for controlling MusicBee remotely, and support for WinAmp plugins. You won't find a more comprehensive free music player, and although it's not open source, it's completely free to use and tinker with for personal use. **Cat Ellis**

FreeMind

A mind-mapping app for planning and managing projects of any size.

FREE | [TINYURL.COM/APC435-FREEM](http://tinyurl.com/APC435-FREEM)

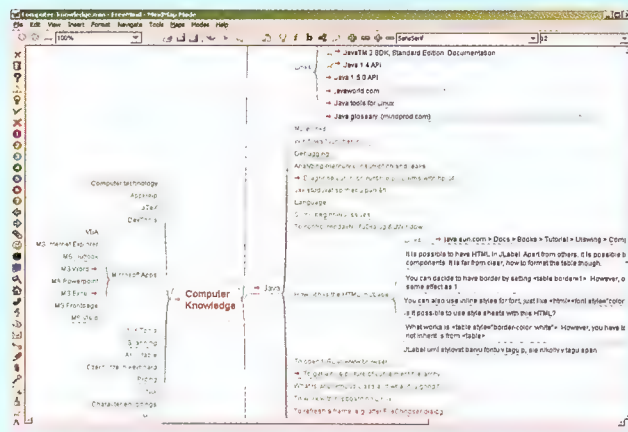


FreeMind is a brilliantly simple mind-mapping tool that can be used to plan anything from a novel to a dream holiday.

Fundamentally, FreeMind uses the familiar system of points (referred to as 'nodes') that branch out from a central topic, with further nodes splitting off each of these.

Looking a little deeper you'll notice branches shift automatically to ensure your nodes are presented in a logical order and you can edit nodes in networks ('batches') that will collapse quickly with a single click. Nodes can be copied and pasted or moved by clicking and dragging – all while preserving their formatting. You can also add HTML hyperlinks or locally stored file locations to your nodes, which is very useful for planning a novel, essay, or other longform writing.

FreeMind includes DES encryption and an automatic backup function to protect your map from accidental data loss while



you're working, but you can also export it as an HTML file to share or utilise from any device.

If all that isn't enough, FreeMind can be expanded even further with plugins like time-management add-ons that let you add reminders to nodes. **Cat Ellis**



Ulysses 2.6

Is this the writing app you've always wanted?

\$69.99 | ULYSSESAPP.COM | NEEDS OS X 10.10 OR LATER



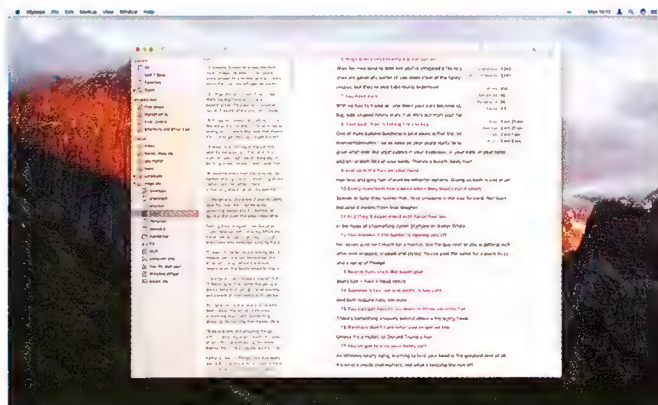
We don't ask much of writing apps; just that they run really fast, look great, don't distract us, support iCloud and Dropbox, export in all the key file formats, work well with online

content management systems, enable us to manage monster projects, and are utterly reliable on our Macs and iOS devices...

At its simplest, Ulysses is a plain text editor. Each document is a sheet, and you can put your sheets in folders and subfolders. You can track character, word, sentence and paragraph counts and reading times, set and track word count targets, attach or embed related files, and export your work as text, HTML, PDF, ePub or DOCX files, or publish to Medium or WordPress (in its hosted and self-hosted varieties). There's a range of styles to change how the app looks, and a typewriter mode to make you feel like Hemingway.

Where the app gets really useful is when you start marking up your text. Ulysses uses the Markdown language, enabling you to add formatting commands very quickly. For example, a hash symbol applies the Heading 1 format, six hashes applies Heading 6; a number and a full stop starts a numbered list; a pointy bracket applies block quote formatting, and so on. On iOS, the on-screen keyboard is extended to provide fast access to the same features.

As you add formatting or links, your work's appearance changes accordingly – with our chosen stylesheet, headings



appear in dark red, links in olive green and code in dark grey. That isn't just useful for writing; it's also useful for reading. We use Ulysses on air for radio broadcasts, for which our scripts' colours make it easy to see what's important.

There are two big benefits of using Markdown. First, it's very lightweight with tiny file sizes, so Ulysses is lightning fast even when you're searching through your entire library of sheets – and it won't have a horrific impact on your online storage if you choose to sync over iCloud or use Dropbox.

The second benefit is that your sheets can be exported in all kinds of ways without you having to make any changes. Fancy a PDF or DOCX file? Pick a template and a page size, and the app converts your formatting to the chosen style. Publishing to an online content management system? Copy your work to the Clipboard and then paste it in, or use the automatic upload ability to send it to WordPress or Medium. Just need text? You have the choice of plain text, rich text, Markdown or TextBundle.

If you're purely a novelist or scriptwriter, we'd recommend Scrivener: we think you'll love it. But if you do other kinds of writing, we think you'll love Ulysses even more.

Gary Marshall

PDF Expert 2

Expert PDF editing? Almost.

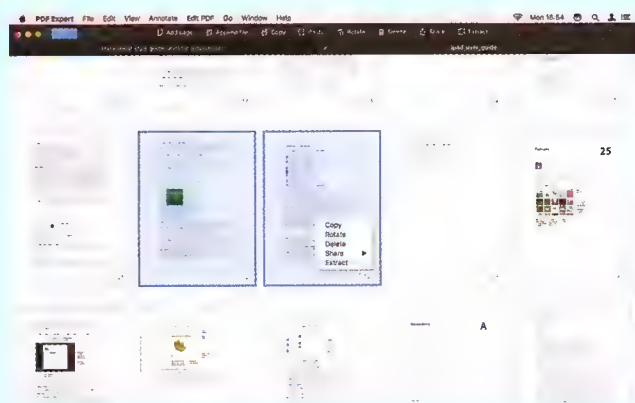
\$89.99 | PDFEXPERT.COM | NEEDS OS X 10.10 OR LATER



The main thing that will strike you about this app is how effortless it is to use. Drop in a PDF and it seems obvious how to go about things. Open the Thumbnails grid view and you can quickly rearrange, rotate, add and delete pages, or append other docs. Extracting specific pages takes but a few seconds.

Double-click a page and you can get cracking on bigger changes, many of which are new to this update. You can add standard annotations, scribbling over items that need correcting, adding notes and signing documents. You can also delve into the PDF's content itself, directly editing existing text, importing images, and converting text and images alike into links to websites or other pages. You can redact content with black bars too, like you're some kind of enforcer of state secrets.

Occasionally, edits don't work perfectly. Updated text in particular can be a problem, because if you lack the original doc's fonts, they'll change to something else, and leading rarely matches.



Although embedded images are easy to replace, backgrounds are untouchable and imagery initially behind text appears in front of it post-edit. For less ambitious editing, though, it's hard to fault this app; it's intuitive, extremely snappy even on ageing Mac hardware, and it won't break the bank.

Craig Grannell



\$13.99

PREVIEW

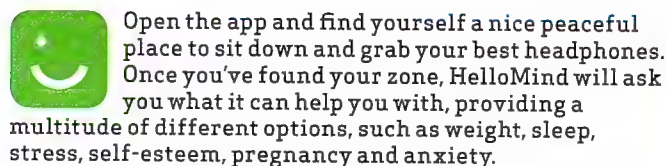
RDH BOOSTER
LISTEN AT BEDTIME

We can harvest a lot of inspiration and good ideas from our dreams. When we dream the more controlling part of our consciousness is put a little on stand-by and the creativity runs through other and

HelloMind

Take back control of your brain
through hypnosis.

FREE WITH IAP | [HELLOMIND.COM](https://www.hellomind.com)



Once you've selected your topic, HelloMind will ask a few more questions based on that topic and then provide what it recommends as a suitable treatment. Each course is of a different duration (some lasting ten sessions, some only one with multiple variations) but all appear to be about \$14 each, which might seem expensive, but not when compared to the cost of an in-person therapist course. The aim is to get you to delve deep into your unconscious mind and find "a whole new way to work with yourself".

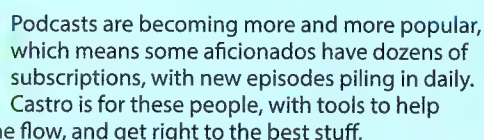
The sessions have no music, so there's nothing to distract you, and just like a proper hypnotherapy session, you can't pause and come back later because that would break your concentration. You can replay sessions, though, so you don't miss out if you have to bail halfway through.

Carmel Sealey

Castro

A podcast app for managing heavy feeds.

\$7.99 | SUPERTOP.CO

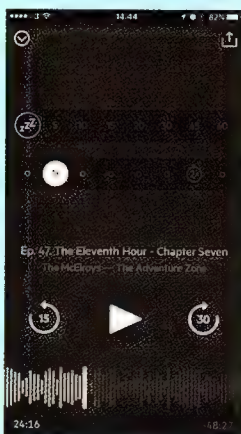


New podcasts arrive in an Inbox, where they're all queued together (rather than being divided by podcast). The queue is in chronological order by default (it can be manually rearranged), but whenever you subscribe to a new podcast, you're given options for how the inbox should prioritise new episodes when they arrive. You can have Castro put that podcast's new episodes right to the top of the queue or the bottom. It can also just archive them right away, so they miss the queue entirely.

These, plus a very understandable layout, are Castro's main pull. A Now Playing bar sits permanently at the bottom, with easy access to speed and sleep options. There's nothing

like rival app Overcast's smart silence removal tool, but if you mostly listen to professional podcasts, it's not a huge miss. Some of Castro's screens could use a little polish, and its minimal use of artwork makes it look a little plain. You can import current podcast subscriptions directly from Apple's Podcast apps, Overcast or with OPML, and can export the latter, too.

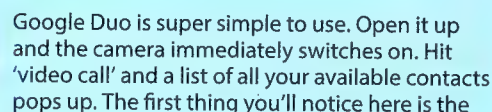
Podcast fanatics will love Castro's Inbox and prioritisation options. Casual listeners will be fine sticking with their device's default option. **Matt Bolton**



Google Duo

A streamlined cross-platform video chat.

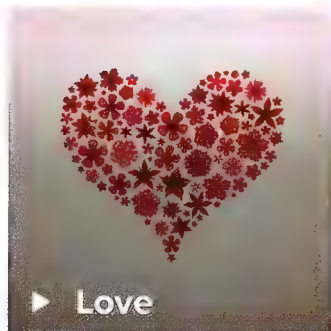
FREE | DUO.GOOGLE.COM



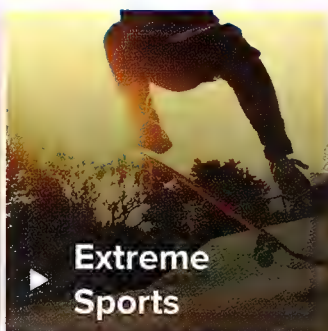
lack of your friends already using Google Duo. (I had only one, and I didn't really want to talk to him. Sorry, mate.) You will need to invite your buddies to also download the app before you can get Facetimeing — I mean Duoing — which is really the only downside to the experience. Duo employs end-to-end encryption and bunny hops between Wi-Fi and mobile data to keep the connection smooth. But the greatest thing about this app is that, unlike Facetime, it's cross-platform, so in theory at least, you can video call anyone else with a smartphone and the app. It also has a great preview ability called Knock Knock, allowing you to see the person calling you (not just an avatar) before accepting the connection. Since this app is so streamlined and simple, there's very little to criticise. **Carmel Sealey**



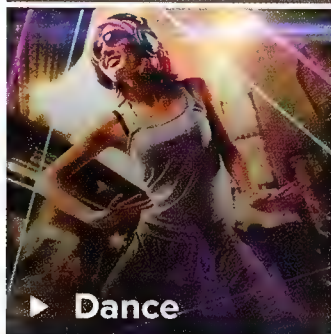
Google Play » ANDROID



► Love



► Extreme Sports



► Dance



► Storyteller



BUSINESS

Magisto

A neat video editor that does all the work.

FREE | WWW.MAGISTO.COM



Equipped with a smartphone and the potential (though rarely the result) of reaching millions, it's not hard to see why user-friendly video editing tools are so popular on smartphones.

Magisto takes 'user friendly' one step further, by basically creating your videos for you. Simply select a handful of videos, images or both on either your phone or Google Drive, and Magisto will, as the name implies, magically transform them into smartly edited videos. There are a number of free editing styles, ranging from 'extreme sports' through to 'love', while other themes are locked behind a paywall (including 'happy birthday' and 'wedding bliss'). Each theme has a selection of music you can use as a soundtrack, though you can opt to choose from your own library, or to select from a library for commercial use. Magisto is structured like a social media platform similar to Instagram – your videos are stored on their servers, rather than on your phone. It's a nice tool, but you'll probably need to convince your friends to use it too. **Shaun Prescott**

Allo

A great, stripped-back but fully featured messaging service from Google.

FREE | ALLO.GOOGLE.COM



Most of us have settled on a messenger app, and our friends have too. Convincing your social circles to decamp to a whole new platform is not easy, but it feels like Allo might make it all worthwhile.

It's beautifully stripped-back, though you're able to riddle your conversations with large emojis, videos and images if you see fit. Messaging can be done individually or in groups, and there's even an incognito mode, which activates encryption. These messages can also be set to auto-delete after a user determined duration, ranging one minute through to a whole day. Allo also has a built-in Assistant, which, while still in beta, is quite useful. Writing "@Google" followed by a search term inside a conversation will bring up relevant results. Write "@Google pub" and it'll show the closest (and best ranked) pub in the user's region. At this early stage, Allo is a great service, and it's likely to get better with time. **Shaun Prescott**

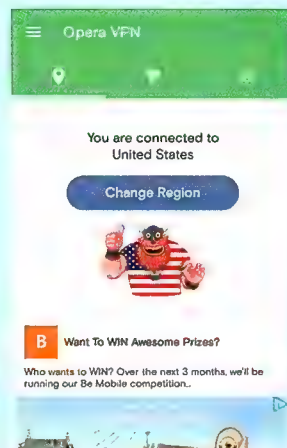
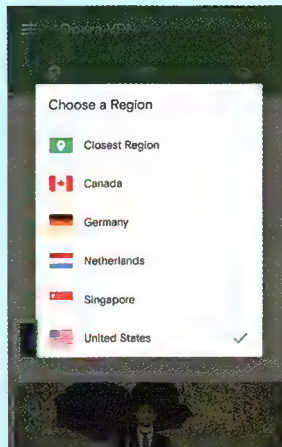
Opera VPN

Get online and protect your searches.

FREE | WWW.OPERA.COM/APPS/VPN



Regular APC readers will know we extoll the virtues of VPNs regularly. Among other things, they're ideal for travellers who need to access servers located at home. Opera VPN is specifically made for your smartphone, rerouting web traffic over both your phone's data connection and Wi-Fi, protecting it from prying eyes and blocking ads. Select a region from one of five on offer (with more to come) and a symbol in your notification bar will tell you that you're connected. It has limitations: you can't access torrents, and Netflix detects that you're going through a proxy. We almost gave up downloading an app from Google Play as the transfer speed was abysmal, though most other uses showed little to no interference. Fans of John Oliver's *Last Week Tonight* will be pleased: an episode of his that was unavailable in Aus was available and streamed flawlessly. **Paul Taylor**





Linux » OPEN-SOURCE SOFTWARE

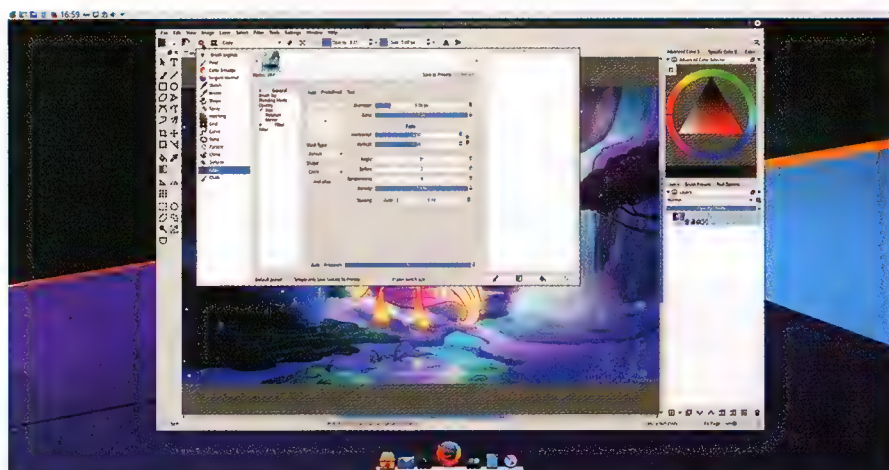
Krita

An open-source image editor to overthrow Photoshop?

FREE | KRITA.ORG

When it comes to editing photos or other sorts of raster images in Linux, most users will tend to think of GIMP. This is understandable as it's one of the most well-known open-source projects. But there's a relatively new GIMP competitor out there with a cute name (which means 'chalk' in Swedish). Krita is part of the Calligra bundle, a KDE-centric office suite, but it's the only bold and actively developed component of that suite while the rest have received far less attention.

Krita is a tool for manipulating images and, of course, you can adjust your holiday photos with it, fix colours, retouch and frame etc, but this application has a strong focus on digital painting – something that's rare in other graphical applications for Linux. Sketches, comics, fantasy artwork, portraits and all other sorts of creative painting can be made in Krita quite



comfortably and with ease. The interface uses the dark theme by default, making Krita look very much like Adobe Photoshop. The left panel stores tools for drawing basic shapes, editing paths, working with selections and, of course, painting.

Krita has some great features right at your fingertips, such as multibrush mode that enables you to draw cool symmetrical patterns within seconds, but perhaps the most powerful feature is Brush settings. Clicking the fourth icon from the left on the horizontal toolbar opens the brush settings dialog. Here, there's a long list of brushes, but also a rich set of options for its so-called 'brush engines'. Krita has at least 16

different 'engines' for achieving various creative effects. For instance, the Krita's analogue of the GIMP's Clone tool is the dedicated Clone engine for the Brush tool, whereas the analogue of the Healing tool is a check box in that engine's options.

There are many more great features in Krita that can't be listed just in a few lines, but nearly everything that's essential to a pro-level graphic software is available, including layers, overlay effects, colour correction, creative filters, complex selection and path tools etc. Even if you're not up to drawing at all, Krita is worth trying thanks to its very clean and welcoming interface.

Alexander Tolstoy

Wine

Windows application layer.

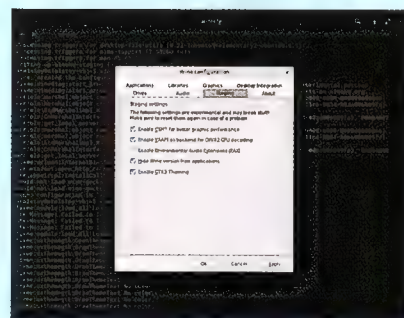
WWW.WINEHQ.ORG | FREE

We've revisited this great project to find out what new fixes and features have been added to it lately. Wine is a rapidly evolving software, growing into a mature and solid release. The way its versions are numbered alludes to minor changes in the 1.9.xx series, but, in fact, Wine's changelog contain enough to make you want to install it. Particularly, now that Wine boasts things such as: a much better GDI performance (which supports DirectDraw and increases the UI's responsiveness); standards-compliant web page rendering using the updated Gecko engine from the recent Firefox version; more shaders supported by Direct3D; a working 5.1-channel output using DirectSound; further fixes in WineD3D (used to wrap

DirectX content to a separate process) and updated Mono version etc.

WineD3D is especially useful for improving the OpenGL performance when running Windows games on Linux. It's no secret that since most productivity applications from the Windows camp have decent replacements from the Linux camp, the most viable use case for installing Wine is gaming. The Wine developers have done a great job during 2016 and closed a magnificent number of bugs relating to current game titles.

Aside from gaming, Wine has an experimental GTK-theming support. There has been theme support previously, but it was buggy and limited only to some Windows XP desktop themes. The GTK themes support means that we can finally get rid of the ugly square look of Windows applications running in Wine and achieve a more uniform look and feel in comparison with what we'd expect to see in Linux. The feature is not mature yet, but for



some GTK 2 engines, it works smoothly and, provided you adjust your fonts antialiasing in Wine, the result can be pleasing.

So if you're keen on gaming on Linux or somehow dependent on an application from the Windows world, keep your Wine installation updated. Wine is also included with nearly all Linux systems.

Alexander Tolstoy



GLORIOUS GAMING GEAR

MASSIVE PC GAMING HARDWARE SHOWDOWN! MONITORS, MICE, KEYBOARDS & HEADSETS ON TEST + COMPREHENSIVE GRAPHICS-CARD BUYER'S GUIDE: GET THE BEST GPU AT ANY BUDGET!

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GORGEOUS GAMING SCREENS

We look at dedicated PC-gaming monitors for gamers looking to get the most from their hobby.

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GRAPHICS CARD BUYER'S GUIDE

Confused by all the GPU options currently on the market? We've made choosing the right one simple with this comprehensive guide.

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GET A GRIP

Want to improve your virtual aim without spending a motza? We test a dozen big-name gaming mice that won't break the bank.

56

KEYS TO THE KINGDOM

When it comes to gaming, there's really only one choice of keyboard. We compare the best mechanical 'boards for under \$170.

64

LOUD AND CLEAR

We test eight pairs of gaming headsets that'll let you hear the action loud and clear.



Gorgeous gaming screens

Lindsay Handmer tests 12 dedicated PC-gaming monitors, designed for gamers looking to get the most from their hobby.

These days, even quite affordable GPUs can consistently push frame rates beyond 60fps, so a screen with a high-enough refresh rate to actually display all the frames is a good start. Gaming monitors also (mostly) include technology such as Nvidia G-Sync and AMD FreeSync, which matches the screens refresh rate to the frame rate coming from the computer. This eliminates a mismatch between the two rates, and ensures a smooth experience without any tearing or stuttering.

Gaming monitors are also focused on having a fast response time, which reduces ghosting. They also offer other gaming focused features, such as on-screen crosshairs and different display modes for each game type. While you won't see a gaming monitor with a resolution under 1,920 x 1,080, 2K (2,560 x 1,440) and 4K (3,840 x 2,160) screens are common. While budget models do without, gaming screens tend to have excellent stands with full height, pivot, swivel and tilt adjustments to get the perfect viewing position.

It's not all kittens and sunshine, though, and all the extra bells and whistles mean gaming monitors typically cost more than their everyday counterparts. Many gaming monitors tend to prioritise low lag and a smooth experience over pure image quality, and many use lower-end (but fast) TN panels. There are some monitors that offer a crossover experience, where they can handle gaming quite well, but also use high-quality panels that have accurate colours needed for other uses.

HOW WE TESTED

Each monitor was tested on a high-end gaming PC, running either an AMD or Nvidia GPU for testing both FreeSync and G-Sync. Connection was via DisplayPort or, where not available, HDMI. Each monitor was tested with a variety of games including *Ashes of the Singularity*, *League of Legends*, *Elite Dangerous*, *StarCraft II*, *Counter Strike* and *GTA V*.



Gaming monitor specs & setup guide

Endless spec comparisons are all well and good, but what are the features you actually need, and how can you set up and get the best from your new gaming monitor? Ultimately, your budget may be the limiting factor, but the first step is to consider your GPU, as well as any future upgrades that will happen while using the same monitor. Your next gaming monitor will likely feature either Nvidia G-Sync or AMD FreeSync – while the former only works with Nvidia GPUs, the latter is based on Adaptive Sync and works with AMD and Intel videocards.

Refresh rate and Response time

Typical monitors refresh the image on the screen 60 times per second, which means they can never display more than 60fps, even if your computer is outputting more. Gaming monitors tend to have higher refresh rates, such as 75Hz, 100Hz, 120Hz, 144Hz or more. This allows the true frame rate to be displayed, for a faster, smoother experience. While important, there is no point getting a 144Hz screen if your GPU struggles to reach 100fps in your favourite games. With response time, lower is better, but anything 5ms (GTG) or less on a gaming screen is good.

Resolution

1080p is great, but higher resolutions up to 4K can give four times as much detail for a truly stunning gaming experience. The problem is it also taxes your GPU a lot more, and a powerful PC is needed to achieve higher frame rates. It can be tricky to compare, but in general, low- to mid-range gaming PCs should stick to 1080p, while mid- to high-end can handle 2K and 4K. Don't forget to consider any future GPU upgrades.

Panel type

For a faster response time and lower prices, many gaming screens use TN panels. While they look pretty good, they do have less accurate colours, shallower viewing angles and lower contrast. The next step up in price is (not very common) VA panels, with better colours, contrast and viewing angles but lower response times. IPS panels give the best image quality and viewing angles, but tend to cost significantly more. Make sure to consider your non-gaming uses (such as video or picture editing) where the higher quality image could be useful.

Screen shape

The latest trend is curved screens, which can be more immersive for gaming, but cost more. Some are even available in ultra-wide 21:9 aspect ratios, which can suit racing games and flight sims. If you plan to use multiple monitors, look for models with thin bezels.

Monitor setup

Most screens come with a bunch of modes for different game types, so have a play and see which you prefer. It's usually worth manually tweaking the settings to get a better image, but it can be rather subjective. (Google your monitor brand for more specific guides.) We tend to favour a lower brightness, with a little more contrast and colours tending towards blue. Windows also has a built-in Color Calibration utility that is worth using and Nvidia has a great guide on further calibration. (www.geforce.com/whats-new/guides/how-to-calibrate-your-monitor)



\$689 | WWW.AOC.COM

Specs: Size: 27" flat; Resolution: 2,560 x 1,440; Panel type: TN; Refresh: 144Hz

AOC AG271QX

A premium option.

Measuring in at 27 inches, the AOC AG271QX is understated and stylish. The simple looking stand actually has both height (130mm), tilt (-3.5/21.5 degrees) and swivel adjustments. The LCD uses a flat TN panel, with a 16:9 aspect ratio and an easy on the eyes 2,560 x 1,440 resolution. The refresh rate is a gamer-friendly 144Hz, it has a 1ms GTG response time, and 8-bit colour is supported.

The AOC features FreeSync, and a G-Sync version is reportedly coming soon. The panel itself is fairly evenly lit, with decent (but of course not IPS-level) colour. There is minimal light bleed, and we didn't experience any ghosting or tearing. It also does a decent job for watching movies, but the lower TN 170/160-degree viewing angles are more noticeable if sitting off-centre.

The screen has a bunch of gamer-focused modes that can reduce input lag (at the

expense of some image quality), or automatically lighten objects in dark areas of a game. The AG271QX also has a USB-powered desktop input switcher and OSD interface, which is pretty handy.

The screen has the usual HDMI (1.4), DVI, DisplayPort (1.2a) and VGA inputs, plus USB 3.0 and 3.5mm audio I/O jacks. One of the USB ports handles fast charging, which makes it a great place to juice up a smartphone when gaming. It also has inbuilt speakers, but they are the same old, same old 3W built-in models that are not much use day to day.

Verdict

A great all round monitor, with plenty of premium extras.



\$495 | WWW.AOC.COM

Specs: Size: 27" flat; Resolution: 1,920 x 1,080; Panel: TN; Refresh: 144Hz

AOC G2770PF

Is it worth saving money with a lower resolution?

Not all gamers want a 2K or 4K resolution and are perfectly happy with 1,920 x 1,080, especially with older GPUs. The AOC G2770PF caters for this by bringing FreeSync and other high-end gaming features to a large but still mostly affordable 27-inch 1080p screen.

The monitor uses a flat TN panel, which gives a fast 1ms response time, has a 1,000:1 contrast ratio (80M:1 dynamic) and the usual 170/160-degree viewing angles. But more importantly, the screen runs at up to 144Hz, for ultra-smooth tear free gaming. It's equipped with FreeSync, which operates from 30Hz to 144Hz, while V-Sync kicks in under 30.

For those used to high res screens, 1080p on a 27-inch model looks a little clunky. But really for many gamers, having a faster framerate and smoother experience (plus savings some purchase dollars) is more important

than greater detail. In testing, the colour is decent, the backlight nice and even, and there was no sign of any ghosting, stuttering or lag. A bit of tweaking in the AOC OSD helps the image, but it's somewhat basic and the interface is frustrating.

On the plus side, the G2770PF has a fantastic stand with height and tilt adjustment. It's also got a USB 3.0 spec hub, plus HDMI, DisplayPort, DVI, D-Sub and some tinny 2W speakers.

The 1080p G2770PF is not a stunning screen, but it has all the bells and whistles of higher-end models, and saves a good \$200 over the same size 2K resolution AOC model.

Verdict

Plenty of great gaming features and 144Hz refresh for those who want a 1080p resolution.





\$450 | WWW.ASUS.COM

Specs: Size: 24" flat; Resolution: 1,920 x 1,080; Panel: TN; Refresh: 144Hz

ASUS MG248Q

Can you do without adaptive sync?

The Nvidia vs AMD debate already rages amongst gamers, and is only made worse by G-Sync and FreeSync. In an effort to be GPU agnostic, the Asus MG248Q ditches both, and instead just has a super-high 144Hz refresh rate. Issues of tearing are handled by V-Sync only, but, of course, it does not actually have to be enabled. The decision means that the monitor is \$200 cheaper than its brethren (such as the ASUS PG248Q) that feature G-Sync.

The MG248Q uses a typical flat 24-inch TN panel, with a 1ms response time and 144Hz refresh rate. Image quality is about normal (not standout, but still good); the backlighting is even and bright.

Testing with even a high-end gaming machine with V-Sync off, tearing and stuttering was not a particular issue. Turning V-Sync on is only worth it for specific problems (say, frame rates exceeding

144fps) but, of course, does not feel as buttery smooth as G-Sync or FreeSync and can introduce input lag. While adaptive sync technologies are great to have, for many gamers, putting the extra money towards a more powerful GPU will bring a greater benefit. The high refresh rate of the MG248Q means it's compatible with Nvidia 3D Vision 2.

The monitor has an excellent OSD (with joystick control) that responds well to tweaking, as well as gamer-focused options, such as a crosshair overlay and FPS counter. It's also worth noting that the stand is particularly nice, with height, tilt, swivel and pivot adjustments.

Verdict

A solid monitor with decent money savings for those who don't need G-Sync or FreeSync.



\$1,779 | WWW.ASUS.COM

Specs: Size: 34" wide; Resolution: 3,440 x 1,440; Panel: IPS 10-bit; Refresh: 100Hz

ASUS RoG Swift PG348Q

Large and in charge.

Ultra-wide monitors for gaming are becoming more popular, and the ASUS PG348Q is one of the best, even considering the eye-watering price. It's a 34-inch monster, with a 3,440 x 1,440 resolution and a 21:9 aspect ratio. For a more immersive experience, it's curved, with a 3,800R rating, and has tiny bezels to make running two side by side even easier.

The panel itself is IPS, with a 0.2325mm pixel pitch, 5ms GTG response time and the ability to display 10-bit colour. For gamers, the LCD is compatible with Nvidia's G-Sync and offers a 100Hz refresh rate.

No surprises, the PG348Q is a gorgeous monitor, with fantastic colour reproduction, deep blacks, even backlighting and loads of detail thanks to the high resolution. For gaming, the 100Hz refresh rate and G-Sync work well to

eliminate any tearing or ghosting, even with the slightly slower response time. The curvature of the screen is not over the top, and helps make the monitor seem larger, get also easier to see, as well as keeping colours and contrast very even. The stand on the ASUS deserves a special mention, as it looks very futuristic (with inbuilt RoG lighting), as well as offering height, tilt and rotation adjustments. Round the back it has the usual HDMI, DisplayPort, USB 3.0 and headphone jack.

The OSD is quite good, with various gaming modes, such as timers, crosshairs and a FPS counter, and other options such as a hardware hotkey to switch between 60Hz and 100Hz.

Verdict

An amazing monitor for widescreen gaming, though the price tag is very steep.





\$649 | WWW.ASUS.COM

Specs: Size: 24" flat; Resolution: 1,920 x 1,080; Panel: TN; Refresh: 180Hz

ASUS RoG Swift PG248Q

For *super* high frame-rate gaming.

Gaming monitors are all about accepting different compromises for a price, and the ASUS PG248Q takes an interesting approach. It's not exactly a budget screen, yet uses a flat TN panel and has a pretty typically 1,920 x 1,080 resolution. The secret sauce is in the refresh rate, which runs up to a very high 180Hz.

To make sure there is no tearing, the screen supports Nvidia's G-Sync, which runs over the full range of frequencies. But the top notch refresh rate means the screen is also compatible with Nvidia 3D Vision 2, for stereoscopic 3D gaming. The panel also has nice low 1ms response time.

In use, the smaller 24-inch size helps hide the TN panels lower viewing angles, and colour reproduction and evenness is quite good and bright. Sure, it's not a stunning picture, but when gaming at +150fps, there isn't time to

stop and check the view. The screen needs a high-end PC to run at high-enough frame rates to make it worthwhile, but looks incredible smooth.

The ASUS PG248Q is equipped with HDMI and DisplayPort 1.2 inputs, as well as a dual USB 3.0 and headphone jacks.

As the RoG model, the screen includes extras such as an on-screen crosshair and FPS counter and an excellent OSD and mini interface joystick. The bezels are also fairly thin, which is ideal for multi-monitor setups. The stand is top notch, with height, tilt, swivel and pivot adjustments.

Verdict

A fantastic monitor for high FPS gaming, but with a hard to swallow price thanks to G-Sync.



\$749 | WWW.BENQ.COM

Specs: Size: 27" flat; Resolution: 2,560 x 1,440; Panel: TN; Refresh: 144Hz

BenQ XL2730Z

Designed for gaming, from top to bottom.

Despite being launched last year, the 27-inch BenQ XL2730Z is one of the more fully featured mid- to high-range monitors on the market. Sure, it's still \$750, but offers a higher-than-normal 2,560 x 1,440 resolution with a super speedy 144Hz refresh rate. To make sure tearing and stuttering can't affect your gaming, it also included FreeSync support.

Underneath, the XL2730Z uses a TN panel, which means a great 1ms response time, but lesser colour accuracy (72% NTSC) and worse viewing angles.

All that really matters, though, is that connecting up to your gaming machine results in a vibrant yet fluid gaming experience. The colours are actually pretty good, all things considered, and there is no evidence of ghosting, input lag or backlight bleed. The XL2730Z includes backlight flickering blur reduction tech (though it does not run

with FreeSync on) that does increase sharpness a little.

But the BenQ boffins didn't stop there, with extra features such as integrated carry handle, a retractable headphone hook, and black equaliser mode to bring out detail in dark areas. The stand is fully adjustable (including pivot) and has dials on the adjustment points so it's easy to reset back to exactly how you like it. The screen has a range of pre-set and configurable OSD calibrations for different games, as well as a handy little remote for quickly switching between them. The XL2730Z can even auto-detect the game type and self-optimize the picture, and back up your custom game modes to the cloud or USB stick.

Verdict

A huge number of gamer-focused features combined into one excellent monitor.





\$249 | WWW.BENQ.COM

Specs: Size: 24" flat; Resolution: 1,920 x 1,080; Panel: TN; Refresh: 60Hz

BenQ RL2455

A gaming screen of a different nature.

While most LCDs are focused entirely on FPS gamers, the BenQ RL2455 recognises that many also want to play other titles. That's not to say the BenQ can't be used for any game, but it is specifically designed with real-time strategies in mind. The 24-inch screen has a very typical 1,920 x 1,080 resolution, using a TN panel with a 1ms GTG response time.

Since super-high frame rates that invite tearing are not the focus, the screen doesn't include any adaptive frame rate tech and sticks with good old 60Hz.

By default, the RL2455 uses a RTS pre-set, designed for *StarCraft II*. Since we hadn't been trounced online in a while, it was also a good place to start testing. The idea behind the screen is that everything from the colours to the contrast ratios are designed to make it easier to see individual units and keep track of frantic RTS gameplay, and

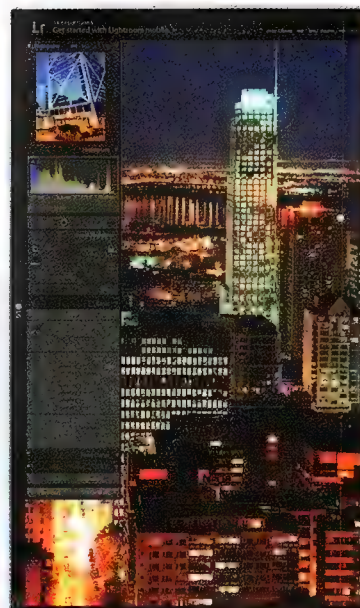
input lag is kept to a minimum.

As it turns out, the RL2455 is noticeably easier on the eyes for RTS gaming, and still works just fine for other titles. Of course, the TN panel is nothing special, but colours are strong, and it's bright and even. The monitor has dual HDMI, DVI and D-Sub, plus a headphone jack, and a basic tilt only base.

For those who play a lot of RTS games, the specialised BenQ RL2455 is worth the investment, but it's a hard sell for those who would prefer to get some other bells and whistles for their money.

Verdict

An affordable choice best suited to hard-core RTS fans.



\$895 | WWW.LG.COM/AU

Specs: Size: 27" flat; Resolution: 3,840 x 2,160; Panel: IPS; Refresh: 60Hz

LG 27UD88

Is resolution more important than response time?

Gaming monitors come in all shapes and sizes, but many cross over between pure entertainment, and productivity-oriented models. The LG 27UD88 boasts FreeSync to eliminate any tearing and stuttering, but then actually only has a 60Hz refresh rate. That's not necessarily an issue, though, since many GPUs will struggle to achieve higher frame rates thanks to the 4K (3,840 x 2,160) resolution.

The LG 27UD88 measures in at 27 inches, with an IPS panel that can display over 99% of the sRGB spectrum and is well suited to graphics hobbyist and professionals.

That's not to say that the screen isn't stunning for gaming, as the high resolution combined with rich accurate colours can show off games to their full potential.

We didn't experience any sync issues, though with FreeSync on, it is a little

smoother. The 5ms GTG response time is also still quite good, and there is no visible ghosting. The LG OSD is quite good, though has fewer gaming-targeted options (though included some different mode pre-sets), and still benefits from a manual calibration. The screen also has black stabilisation, which can make it easier to see detail in dark areas when gaming, and dynamic action sync, which reduces input lag.

One unique feature of the LG 27UD88 is a USB Type-C port that can handle video, data transfers and even charge a device. While not useful for gaming, it's a great way to link a laptop up to the big screen without messing around with HDMI cables.

Verdict

Basic but essential gaming features, with premium image quality for those who need it.





\$995 | WWW.LG.COM

Specs: Size: 34" ultra-wide; Resolution: 3,440 x 1,440; Panel: IPS; Refresh: 60Hz

LG 34UM88C

An ultra-wide gaming experience.

While most monitors stick to the tried and true 16:9, more and more are coming out in widescreen 21:9 aspect ratios. The LG 34UM88C has a high 3,440 x 1,440 resolution and IPS panel, but unlike some of the competition, uses a flat LCD. The monitor is also available with a curved screen (the LG 34UC88-B) with otherwise almost identical specs, but a \$300 price hike.

While the 34UM88C includes AMD FreeSync for smoother gaming, the refresh rate is an otherwise bog-standard 60Hz. Sure, at the higher resolution mid-range gaming PCs will struggle to break 60fps on some titles, but it still feels a little low. Part of the reason is that the LG is also targeted towards those who want a high-quality image for uses outside of gaming.

Still, the rich colours and wide screen of the 34UM88C make for an immersive experience, but we still miss

the curve. Not that we really experienced any tearing or stuttering with it turned off, but FreeSync does make a noticeable difference, and runs from 40Hz to 60Hz.

The monitor also has some other handy features for gamers, such as modes for FPS or RTS gaming, a black stabiliser that lightens dark areas, and a mode to reduce input lag for games that need every last bit of precision. The screen also has quite decent speakers, and handy USB 3.0 quick charging.

The 34UM88C is significantly cheaper than its 34-inch widescreen competition, but then lacks a higher-end refresh rate and a curved panel.

Verdict

Great image quality, with a side of FreeSync-supported widescreen gaming.



\$299 | WWW.SAMSUNG.COM

Specs: Size: 24" curved; Resolution: 1,920 x 1,080; Panel: VA; Refresh: 60Hz

Samsung LC24F390

Is it worth compromising for curves?

With a 24-inch curved VA screen just 11.9mm thick and a sharp 1,920 x 1,080 resolution, the Samsung LC24F390 looks gorgeous. Colour reproduction and contrast are a big step up from TN panels (though still 72% NTSC), and the curve only accentuates the wider viewing angles.

While the dynamic contrast ratios are only given as 'Mega', the base 3,000:1 ratio is still way above most affordable screens. Of course, there are some trade-offs, such as a slower 5ms response and a 250cd/m2 brightness. The other catch is that the LC24F390 only has a 60Hz refresh rate, which is pretty boring amongst its brethren.

It still lays claim to the 'gaming' title though, thanks to the inclusion of FreeSync. That said, it's a screen for those who want to game casually, but also have a great quality panel the rest of the time without paying IPS prices.

Frustratingly, Samsung does not state the exact frequency range that FreeSync works for. In testing, we struggled to spot the switch to V-Sync (which is a good thing), and the screen gave a pretty good experience.

The minimalistic Samsung stand looks great, but only has basic tilt adjustment. The OSD is quite comprehensive (though the picture is hard to improve) and easy to navigate thanks to the joystick style input. The inputs are annoyingly lacking, with just a single HDMI, and VGA, of all things...

The screen is also available as a 21.5- and a 27-inch model, for \$50 less and more, respectively.

Verdict

A pleasing mix between gaming and image quality at an affordable price.





\$169 | WWW.VIEWSONIC.COM.AU

Specs: Size: 24" flat; Resolution: 1,920 x 1,080; Panel: TN; Refresh: 75Hz

ViewSonic VX2457-mhd

Perfect for budget-conscious gamers.

Squeezing the latest tech into a monitor is tricky enough as is, but the ViewSonic VX2457-mhd manages it at a very affordable price. Sure, it has a 1,920 x 1,080 resolution and a TN panel, but that also means a super-fast 1ms response time. The real standout feature is the 75Hz refresh rate, along with FreeSync support from 47Hz to 75Hz. In other words, the VX2457-mhd is perfectly suited to lower-end gamers, who want to push frame rates beyond 60fps with their AMD GPUs, but aren't looking to hit 120Hz and beyond.

It's actually an excellent combo, and in our testing, tearing and stuttering was completely eliminated. Frustratingly, though, to keep costs down, there is no DisplayPort cable included in the box, which is needed to use FreeSync.

In general, though, the matte display offers strong colours and good image

quality for the price and is even better after some (fiddly) OSD tweaking. The screen is also quite bright, with only tiny amounts of backlight bleed around the edges.

The VX2457-mhd has the usual HDMI, DisplayPort and VGA inputs, a pair of tinny 2W speakers and a stand with only basic tilt adjustments.

Happily, for those who like a different size, the monitor is also available as a 27-inch version for \$80 more, but funnily enough, the smaller 21.5-inch model costs the same as the 24-inch. All three are covered by an excellent 30-day pixel perfect guarantee and three-year warranty.

Verdict

Considering the bargain price, the VX2457 offers a compelling feature set for AMD gamers.



\$399 | WWW.VIEWSONIC.COM.AU

Specs: Size: 23.6" flat; Resolution: 1,920 x 1,080; Panel: TN; Refresh: 144Hz

ViewSonic XG2401

Premium features on an affordable budget.

Not everyone wants a huge 27-inch or larger screen, and the ViewSonic XG2401 is a very manageable 24 inches. Its gaming credentials come in the form of an excellent 144Hz refresh rate, and Adaptive Sync (supporting FreeSync) for tear free gaming.

Under the rather staid looking shell (aside from the red highlights), the XG2401 has a TN panel with a 1,920 x 1,080 resolution and 1ms response time. While the viewing angles are as expected, the slightly smaller size means that colour reproduction and brightness take a fair bit of off-angle viewing before they are affected. Where the monitor really shines is with super-high FPS gaming, though you do need an AMD GPU. As you head north of 100fps, the smoothness becomes apparent, with little sign of judder or ghosting. The screen has also been designed to reduce any input lag as much as

possible, for the best gaming experience.

The XG2401 OSD is quite comprehensive (and benefits from a tweak) including FPS, RTS and MOBA modes — though the buttons themselves can be a bit fiddly to use.

The ViewSonic designers have not forgotten about the little extras either, and the stand has the full range of adjustments, there is a clutter reducing cable ring, plus USB 3.0 hub. Twin HDMI ports are also a nice extra, alongside the DisplayPort connection.

While there are larger screens and cheaper screens, the ViewSonic XG2401 walks the fine line between both quite well, without missing out on any extras.

Verdict

A great choice for gamers who want to push their frame rates on a smaller screen.





Graphics card buyer's guide

Confused by all the GPU options currently on the market? The APC team makes choosing the right one simple with this comprehensive and (mostly) jargon-free guide.

With both AMD and Nvidia having launched their latest GPU architectures within the last six months (codenamed Polaris and Pascal, respectively), now is a great time to upgrade – especially if you're aiming for the competitive budget or mid-range space. Enough time has passed that initially-high launch prices have largely subsided, so there are some genuine bargains to be had too.

More formats and resolutions than ever before – the proliferation of ultrawidescreen displays means it's no longer just 1080p, 1440p and 4K. You've now got newfangled ultrawide 21:9 aspect-ratio models (which are commonly either 2,560 x 1,080 pixels or 3,440 x 1,440 pixels) that demand more GPU grunt, not to mention the burgeoning VR market.

HOW FAST IS FAST ENOUGH?

With any graphics card purchase, your ultimate goal should be to maintain an average framerate above 60fps in mainstream games, and you really don't want that number dropping below 30fps at any time – doing so means you'll really start to feel the slowdown in the gameplay and it makes for a frankly crappy gaming experience.

With the bulk of PC monitors still 1080p models – or 1,920 x 1,080 pixels – for most of us, a high-end graphics card like the GeForce GTX 1080 is overkill. You can get much better bang-for-buck at the \$300–\$400 mark, but you don't even need to spend that much to get solid speeds at 1080p. On the other hand, when paired with a high-refresh-rate monitor,

higher framerates can arguably improve the overall experience, making games feel faster and more responsive – and you mightn't need to spend a fortune to get on board this revolution, with HFR monitors starting at \$250.

WHEN TO UPGRADE

To keep on top of modern graphics upgrades, most PC gamers will want to upgrade their GPU every two to three years. Driver upgrades tend to eek more performance out of cards over time, but these can only go so far.

When exactly you should upgrade is going to vary significantly from person to person, but the general rule is that, if your current setup can no longer maintain 60fps at Medium detail settings, it's worth investigating the current GPU scene.

IS OVERCLOCKED WORTH IT?

This is really a question of how much you're being asked to pay. While higher clocks does indeed generally mean more FPS, out of the factory, most overclocked cards only offer a modest speed increase in the range of 2–5%. What you're really paying for is the chance of achieving higher speeds manually thanks to better cooling hardware and higher-quality power components.

That said, you'll be lucky to eek more than about 10–15% of an increase from most GPUs and their accompanying memory – remember that both need to be bumped up to see a consistent increase in framerates. Generally, then, you shouldn't pay more than 15% more for an overclocked card.



\$210 (EST.) | WWW.GEFORCE.COM

BEST BUDGET OPTION (AROUND \$200)

Nvidia GeForce GTX 1050 Ti

1080p at 60fps for next to nix.

This \$200 price point is about as low as you can go, but you can still pick up what's considered a 'real' gaming GPU. For budget gamers, what you're aiming for is a card that can average around 60fps at 1080p in modern games — and you can generally get that, provided you turn the detail settings down to Medium/Normal.

That said, this category actually turned out to be the hardest for us to make a clear recommendation for this month, primarily due to two factors. The first is that Nvidia only just announced its budget Pascal cards (the GTX 1050 and 1050 Ti) right as we were going to print, so we've not had a chance to benchmark them yet.

The second is that AMD's competing RX 460 isn't a great card. While it doesn't require much power and does manage to squeak in by delivering 60.3fps at Medium in our 16-game average, it has only half the stream processors and

performance of the RX 470, but still ultimately costs two-thirds the price. In many games, it's only marginally ahead of the last-gen GeForce GTX 950. That makes it quite poor value on an FPS-per-dollar scale — and one we'd avoid.

Moreover, based on the official specs and some early leaked benchmark results, the GTX 1050 and higher-end 1050 Ti both look to outperform the RX 460 — the Ti by significant margins. The latter looks like it'll come in at around \$210 locally, so it'll be a much better budget buy.

We'll have a full review next month, but consider this a tentative recommendation for the 1050 Ti.



\$300 | WWW.AMD.COM

BEST LOWER-MIDRANGE (AROUND \$300)

AMD Radeon RX 470

AMD's appealing all-rounder.

At the time we went to print, AMD's Radeon RX 470 was pretty much untouchable at this \$300 price point and, in the US, AMD has just dropped the price slightly — likely in the hopes that it'll tempt some potential GTX 1050 Ti buyers up — so it should be even more competitive by the time you're reading this guide.

This is basically a slightly cut-down version of the RX 480, making it a comfortable 1080p/Ultra card — it's able to clear most modern games at 70fps with those settings, and it can even stretch to 1440p in many titles at Medium details. Most 470s require a 6- or 8-pin power connector. On a frames-per-dollar metric, the RX 470 is second from the top on our list, making this one top-value offering.

That said, it'd be remiss of us if we didn't point out that prices on the 3GB variant of the GTX 1060 are coming pretty close to the \$300 mark. The cost of the latter

has continued to slip since its launch in August, and you can find super-budget options from vendors like Sapphire and XFX starting at \$320 online. Measured on our frames-per-dollar metric across 16 games, the 3GB 1060 is actually the best-value card currently on the market — provided you don't pay over \$320.

Cards from the major-three (MSI, Gigabyte and ASUS) are all generally over \$350, though, so if you're going to spend that much, you might as well jump up to our recommendation in the \$400 category...

After all, this is Corsair, a company that, for the last few years, has been the king of cool when it comes to aesthetic design.



\$370 | WWW.NVIDIA.COM

BEST UPPER-MIDRANGE (AROUND \$400)

Nvidia GeForce GTX 1060 (6GB)

Room to expand.

Creeping up to around \$400 will net you a card that can do 1080p with absolutely all the bells and whistles, and also offer breathing room to keep that up in future titles that are a bit more demanding. Alternatively, if you're using a higher-definition 1440p screen or a 27-inch ultrawide, spending this much on a GPU should generally let you play at High detail settings.

In this space, you've basically got two \$370 cards going head to head: the Radeon RX 480 with 4GB of memory, and the GeForce GTX 1060 with 6GB of memory. While there's also an 8GB version of the RX 480, it doesn't actually complicate things: at \$430, it's nearly 15% more expensive, but in most current games, it doesn't improve framerates more than a percent or two over the 4GB edition. It's not worth the extra \$60.

Coming back to that main contest then, it sometimes

a close competition, but ultimately the 1060 pulled ahead enough of the time to crack a 10% lead across our 16-game suite at 1080p and slightly less at 1440p and 4K (not that the latter is playable).

While an overclocked RX 480 can close that difference, the 1060 is no slouch when it comes to overclocking itself, opening up the same 10% gap.

While the RX 480 does actually deliver decent value on a cost-per-frame scale, it's been outcompeted by the 1060 at this price.

Astute readers may also have seen the Radeon R9 390 selling at around \$410, but it's no match for the 6GB GTX 1060 either.



FROM \$630 | WWW.NVIDIA.COM

BEST PREMIUM (AROUND \$600)

Nvidia GeForce GTX 1070

For VR and (a bit) beyond.

We're getting up into the big leagues at this \$600 price point and, to be completely honest, it's probably overkill to spend this much on a graphics card if you're only gaming at 1080p — unless, of course, you want to take advantage of high-framerate (HFR) techs like G-Sync and FreeSync.

If you've got a higher-res monitor, you will be able to achieve very comfortable 1440p/Ultra gaming at this price, and you can even manage 4K resolution at Medium detail settings. This is also the kind of card you'll need to aim for if you're buying one of the new 32-inch ultrawide displays, which generally come at a resolution of 3,440 x 1,400 pixels.

At present, this price range is a bit of a one-horse race for Nvidia. With AMD's R9 Fury cards now all approaching 18-months old, they're not particularly competitive anymore —

their Polaris replacements should hopefully arrive in the next few months.

But in the interim, there's really only one choice: the GeForce GTX 1070. It's faster than last-generation's GTX 980 Ti and Titan X, has an ample 8GB of memory and proves to be an impressive overclocker too.

Even at 4K resolution, we were able to squeeze an extra 13% out of our test card (using only a single 8-pin power connector), for an average framerate of 50.2fps — decidedly playable, if not always buttery-smooth. 1080p performance approached a glorious 120fps.

If you want HFR or 4K gaming on a budget, this is the most economical option you'll find.



\$1,050 | WWW.NVIDIA.COM

IF MONEY IS NO OBJECT

Nvidia GeForce GTX 1080

4K and HFR, here we come!

If you're looking to blow the budget on a top-level card, there's at least some reassurance that you can't really put a foot wrong when it comes to the GeForce GTX 1080. As with the GTX 1070, AMD doesn't yet have any Polaris cards that can compete against Nvidia's flagship, with the Radeon company seemingly content to focus on the midrange and entry-level markets for the time being.

However, given the 1080 is a whopping \$400 more than the 1070, the question really becomes one of how excessive you want to get. In other words, should you go for a single GTX 1080 for around \$1,050, or splash out another \$200 or so for a pair of GTX 1070s.

That depends on your requirements. If you're gaming at 4K or on a larger ultrawide, a single overclocked GTX 1080 can net you a 60fps average in most games — across our 16-title suite, our 4K

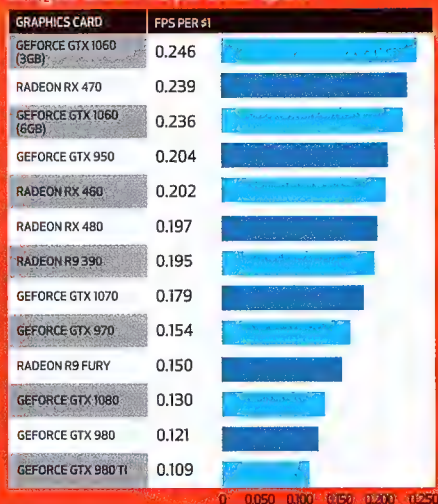
average was 60.6fps, while a pair of 1070s in SLI output 69fps.

There are still a lot of caveats with SLI, though, like the need for a beefier PSU (although an 850W will be ample of two 1070s), the fact that game support isn't universal and, moreover, that SLI tech still doesn't work with VR. You'll also want to pick up an HB bridge, for around \$60, to ensure the best SLI performance.

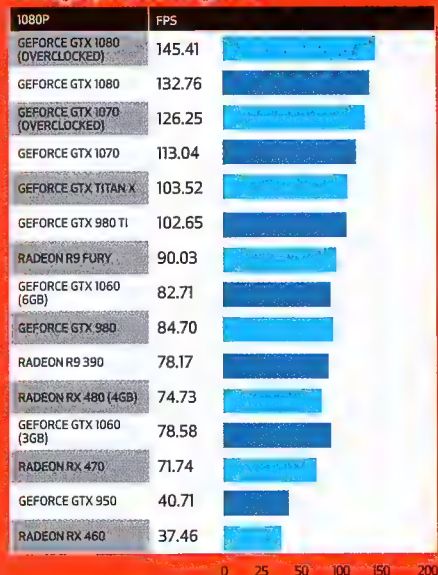
The GTX 1080 is the safer, simpler bet, then, and the one we'd recommend for most setups — and if you go the SLI route, be prepared to have to tinker and troubleshoot.

LABS BENCHMARK RESULTS

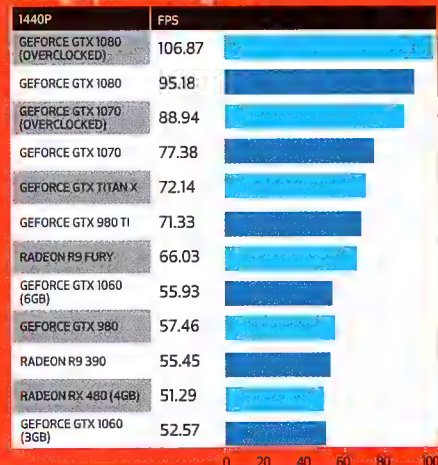
Single 16-bit FPS per dollar spent



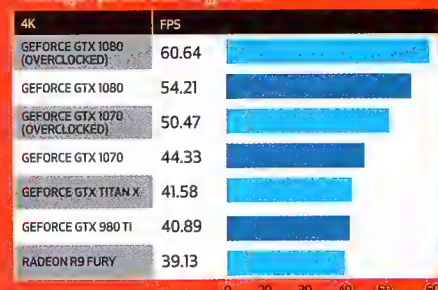
Average fps across 16 games



Average fps across 16 games



Average fps across 16 games





Get a grip

Want to improve your virtual aim without spending a motza? Bennett Ring tests a dozen big-name gaming mice that won't break the bank.

If there's one segment of PC hardware that's booming, it's gaming mice (and keyboards). Gaming is one of the key areas of hardware that is still experiencing growth, so there are now dozens of different gaming mice on the market — and they're not all equal. Compared to regular gaming mice, you'll first notice the price. They range between \$40 and \$350, so we've decided to focus on budget mice under \$100. They usually use special sensors that are far more accurate than a regular office mouse, and come decked out with features designed primarily for gamers — extra keys, the ability to record several mouse clicks into one button press (called a macro) and, of course, lots of RGB lights.

When it comes to gaming mice, there are several main variants. There are those that come festooned with buttons, some including upwards of 15 or more, and they're mainly designed for MOBA and MMO players, who need to bind a lot of different spells and actions so they can be activated with a quick button press. We're also starting to see a divide between optical and laser sensors, which we'll go into more detail soon. There are also gaming mice designed for the various way gamers hold them — claw and palm grip being the most common. Again, we'll explain what this means a little later. If you're serious about racking up headshots or coming top of the scoreboard in your game of choice, a quality gaming mouse will go a long

way to help that happen. Let's take a look at the key specs that separate these mice from each other.

HOW WE TESTED

There are no benchmarks available to test mice, so we had to use real games to see how they felt. We used *Battlefield 4*, *World of Warcraft* and *League of Legends* to see how each mouse felt — were they accurate, easy to reach the buttons, easy to configure and comfortable over extended periods of time? To be frank, all of the sensors in today's mice are, quite simply, brilliant. It was extremely difficult to notice any difference in tracking, so we measured each mouse on its comfort, features, price and software.

Get your mouse set up for success

We reveal what the specs mean and what to adjust mouse performance and feel.

The most obvious specification that gaming mice manufacturers like to push is the DPI, or dots per inch. In the old days, mice used a ball that connected to twin rollers to measure movement, but this has since been replaced by a light and camera. As the mouse moves, the camera takes hundreds if not thousands of pictures per second, checking to see where the mouse light has moved. The DPI measures just how many shots are taken. Increase the DPI, and the further your mouse will move when you slide it across your mouse pad. Therefore, a higher DPI will react to smaller movements.

How high is too high?

It's usually splashed across the mouse packaging, and most people assume that the higher the DPI, the better the sensor, but this is not always the case. Many mice now offer a DPI of 8,000, and yet, pro-gamers generally set their DPI to no more than 1,200. It can be helpful if you're running a 4K screen, or three screens, but for a single screen user a high DPI can actually be a hindrance, as the mouse becomes overly sensitive.

Nearly every mouse now comes with a DPI-adjusting button, which allows the users to switch the DPI on the fly while gaming. For example, there's generally three DPI modes that the user can pre-program. In the example of an FPS player, they may set

a 600 DPI mode for ultra-fine accuracy while sniping, 1,000 for general run and gunning, and 1,600 for flying around in vehicles that require wide-ranging mouse movements.

Optical or laser?

Amongst the gaming community, debate is raging about optical versus digital or laser mice. Optical mice shine a red light onto the mouse pad, while laser mice instead use infrared light. According to a recent interview with Chris Pate, of Logitech, "Both optical and laser-illuminated mice use CMOS sensors to take pictures of the surface beneath them, and use those pictures to determine movement". Laser lights have a different wavelength to the optical lights used in other mice, and looks

deeper into the structure of the surface it's on. However, an optical sensor looks more at the top of the surface, which can make laser lights more sensitive to dips and troughs in your surface, leading to jittering. This is why laser-based mice work better on hard mouse pads — put them on a fabric pad and it picks up too much information, which can lead a phenomenon most gamers call unwanted acceleration. According to Logitech, laser sensors have 5% variation in tracking at different speeds, while optical is below 1%. This is why most serious gamers are making the move back to optical mouse. The issue isn't actually acceleration — it's also known as 'resolution error versus speed' and 'speed-related accuracy

variance', but for the purposes of this article, we'll keep it simple.

Local polling

The other main spec that is promoted is the polling rate — how often the mouse sends data to your PC. Thankfully, basically every mouse on the planet now does this at 1,000Hz, so it's basically irrelevant. You'll probably notice that every mouse in our roundup is wired as well, for two reasons. Firstly, wireless mice tend to cost a lot more. Secondly, there's a perception that they introduce latency between a user's input and what happens on screen, though several high-end wireless mouse claim this is around 1ms.

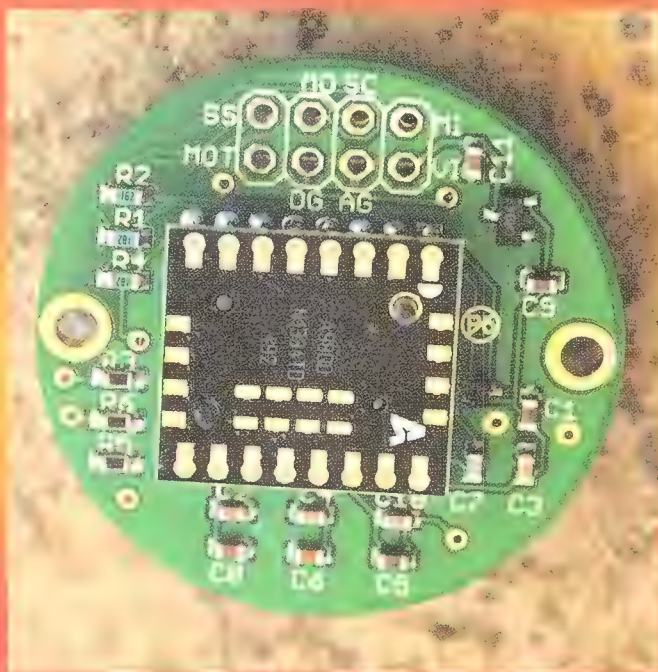
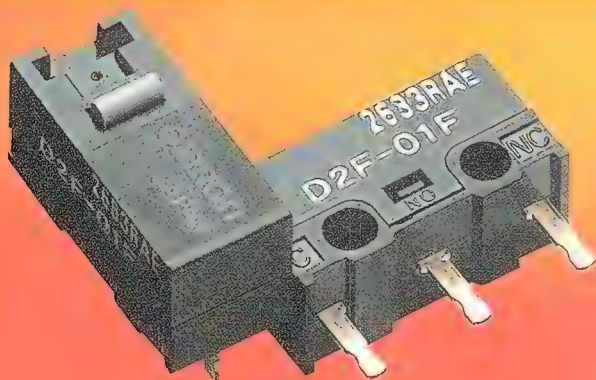
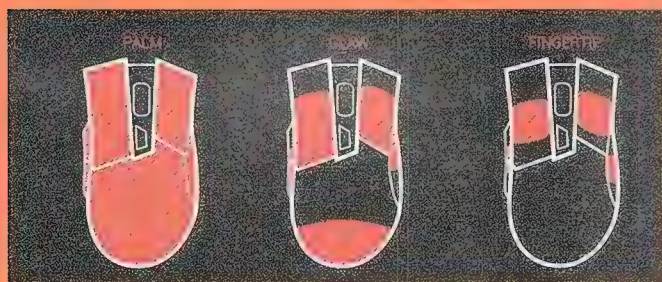
Get comfortable

Another key factor that comes into play when buying a mouse

is ergonomics — if it doesn't feel comfortable after hours of play, you're going to have an unpleasant experience. Claw gamers tend to hold the mouse with the tips of their fingers, while palm gamers wrest their entire palm on the mouse — figure out which one you are, and then buy the optimal shape for your needs. Fingertip gamers tend to hold the mouse with the slightest of touch.

MMOre buttons

Finally, there's the number of buttons on the mouse. Shooter fans tend to only need four or five, while MMO players can make use of three times that. Again, it comes down to what kind of game you play — choose the one most appropriate for your needs.



Specs: Sensor type: Optical; DPI: Up to 6,400; Number of buttons: 6



\$79 | WWW.ASUS.COM/AU

ASUS Gladius

Simple, to the point, but a tad expensive.

Designed for right-handers, this mouse will apparently fit well with both claw and palm gamers, but we definitely found it a better fit for palm users.

For the price, we're a little surprised at the lack of buttons – there's just two on the left-hand side for thumb use, along with a DPI switcher behind the scroll wheel, and the main two buttons. It apparently uses 'slide to switch' buttons, which are meant to have a special shape that allows you to slide your thumb to press the side buttons, but we didn't really notice much of a difference.

Another slight flaw is the DPI selection – this mouse can only handle two mouse DPI profiles, whereas most offer three, and some even more. The USB 2.0 cable is detachable, while the Asus RoG Armoury software is one of the easiest we've used. It even includes surface calibration to ensure the sensor is

perfectly tuned to your gaming mouse pad.

The scroll wheel has a nice solid feel to it, but can't be moved sideways – it's either back, front or click in, whereas other mice can also move sideways. Asus includes two extra Omron switches to go under the main left and right buttons that deliver slightly different resistance, which is a very nice touch.

Considering the price, we were expecting a little more from this mouse. The exchangeable switches are a very nice touch, but it's rather basic for one of the more expensive mice in the roundup.

Verdict

A good shape, but ultimately expensive for what you get.



Specs: Sensor type: Optical; DPI: Up to 6,400; Number of buttons: 5



\$89 | WWW.ZOWIE.BENQ.COM

BenQ ZA13

You put the DPI button where?!

Left handers can finally rejoice, as BenQ's new Zowie ZA13 is one of the few ambidextrous mice on the market. It's available in a wide range of sizes as well, to fit perfectly into your individually sized hands. Thanks to our tester's lady-like mitts, we received one of the smaller models, and it fit perfectly in the hand. Designed for claw and palm users, fingertip gamers might like to look elsewhere, though it's so small and light, we think it'd be quite usable for all.

It's a very, very simply mouse, with the main left/right buttons, twin buttons on each side. Sadly, though, when we received our sample, this product was so new that there was no software, so we couldn't test how well the DPI adjustment worked. It was stuck on an extremely low sensitivity, which led to unplayable gameplay. However, BenQ promises that it supports 400/800/1,600/3,200dpi

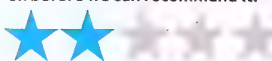
adjustment, so we can't really say how well it will feel at higher DPI levels.

Eventually, we figured out that the DPI adjustment is via a button on the bottom of the mouse, which is quite possibly the worst place to put it. Who wants to lift their mouse up mid-battle, just to change the DPI? Once we'd cranked it up, it was a lot more usable, but the positioning of this button is simply insane.

With a DPI button in the most ridiculous spot, and a lack of software support (at least for now), we simply can't recommend this mouse to gamers.

Verdict

Software support will help this mouse, but it has a lot to improve on before we can recommend it.



Specs: Sensor type: Laser; DPI: Up to 12,000; Number of buttons: 8



\$85 | WWW.COOLERMASTER.COM

CoolerMaster MasterMouse Pro

Make it yours.

Say hello to one of the most configurable mice on the market. CoolerMaster certainly aren't messing about with their new catch cry, "Make it yours". Opening the box reveals a fairly standard looking mouse, but it's the accessories that make all the difference.

Don't like the shape of the mouse? Then swap it out for the full shell that fits over the top of it. There's also two side panels that can be switched as well, allowing the user to build a mouse that fits their hand perfectly. And yet, once again, we see a company put the DPI switcher on the bottom of the mouse – seriously? Thankfully, this can be remapped to the seven other buttons, though, so you won't be lifting your mouse in the midst of a firefight.

A 'Storm TX' button allows the user to assign an extra key function to every button, effectively doubling the number of buttons on

the mouse. The software is extremely detailed, offering advanced features like lift-off distance and angle snapping, which isn't always included with other mice. Recording macros couldn't be simpler, and it's possible to build up different macro profiles depending on which game you're playing.

Our only concern is the mouse is extremely light – it feels a little cheap to be frank. For sheer perfection, we'd have loved to see removable weights so that users could make it just the right weight for their preferred style.

Still, at just \$85 and being one of the most configurable mice on the market, CoolerMaster is on to a winner with this little beauty.

Verdict

Problematic DPI button can be remapped and feels a bit light, but its customisability is a major boon.



Specs: Sensor type: Optical; DPI: Up to 12,000; Number of buttons: 8



\$85 | WWW.CORSAIR.COM

Corsair M65 Pro

Everything you could want, and more.

Finally, a mouse with removable weights! Corsair has included three removable weights across the bottom of this mouse, allowing the user to make it feel just right. It's for right-handers (sorry lefties), and comes with Corsair's obsession for RGB lighting – once we plugged it in, it synched with the Corsair keyboard we were using, pulsing to life.

Corsair has decked this out with extra large PTFE glide pads, which means it'll slide across your mouse pad like butter in a frying pan. The ergonomics are a little different, so we'd recommend you try it before buying it, though as a palm gamer, it felt great.

Despite using an optical sensor, Corsair has used software trickery to increase the DPI to a whopping 12,000, not that anybody would ever go so high. We love the sniping button on the left side – hit this, and the DPI drops nice and low, making every shot

count. Speaking of buttons, there's plenty here, with eight in total.

The Corsair Utility Engine is one of the most advanced on the market, allowing you to share profiles online with other players, and opening up all of the most advanced options we've seen on a mouse. Again, we really love the surface calibration feature, which optimises the mouse for your specific mouse pad. If you like the ergonomics of this mouse, we can highly recommend it – just make sure the glove fits before laying down your dollars.

Verdict

A right-hander mouse with super high DPI, but the shape requires testing before purchase.



Specs: Sensor type: Optical; DPI: Up to 6,400; Number of buttons: 6



\$49 | WWW.GIGABYTE.COM.AU

Gigabyte XM300

Cheap but not nasty.

As soon as we picked up this mouse, we could tell there wasn't quite the quality on offer of the more expensive mice. It's not that it feels shoddily made, it's just a tad bit light, and there's not a lot that it can do.

At the heart of this mouse is an optical sensor that offers 50 DPI adjustments; most other mice only handle 100 DPI adjustments. It's a right-hander, with no capacity to be used by lefties, and there's not a lot of buttons. The all-plastic design isn't quite as comfy as some of the other mice, though there is a small strip of rubber on the left side to rest your thumb. Like most of today's mice, it uses Omron switches that are rated to handle 20 million clicks, so should keep you going well into retirement. It's also got the full 20 gazillion colours offered by RGB (16.7 million to be exact).

Gigabyte has designed this mouse for use by all

three types of gamers – palm, claw and finger tip. It's nice to see they've put the DPI adjust buttons in the traditional area, next to the scroll wheel, and a series of four LEDs light up to show which DPI mode you've selected. Unfortunately, the software isn't quite as clever as some of the other mice, but at this price, we're not complaining.

Gigabyte has delivered an affordable gaming mouse that will do the job, but lacks the key features such as adjustability that come with those twice its price.

Verdict

At this price, its lack of features is expected. It's light but compatible with all gripping styles.



Specs: Sensor type: Optical; DPI: Up to 12,000; Number of buttons: 6



\$99 | EN-AU.LOGITECH.COM

Logitech G403 Prodigy

Big dollars, small features.

We're really struggling to figure out how Logitech can charge \$100 for one of the simplest mice in the roundup. It's yet another right-hander, and there's just one extra feature in the box to customise it – a small 10-gram weight that lifts the total weight from 90 grams to 100 grams. We remember the days when Logitech had a small tray filled with about six different weights, making them much more configurable.

We must admit it does have one of the smoothest sensations of sliding across our FUNC mouse mat, but there's very little else to impress. Logitech claims it has a 1ms mouse response time, yet we didn't notice any difference in-game. It did seem a tiny bit more accurate when pulling off long-range headshots, but barely so.

We're not sure if it's optical or laser, but we're guessing the latter, as it has a maximum DPI of 12,000 –

most optical mice are limited to half that. Like many of the mice here, it comes with onboard memory, so that once you've finished programming it, you can take it to a pal's place and not have to worry about setting up all of your profiles again. It's also got configurable RGB lighting, but it's much more subtle than the competition. The 260MB of bloatware it installs, however, isn't very desirable.

With just six buttons, this mouse comes out in the middle of the pack in terms of button numbers. And yet... there's something about how smooth this mouse feels in use that does make a difference. Whether that difference justifies the \$100 price tag is arguable, though.

Verdict

With only one extra feature on offer here, this mouse is simply too expensive, despite its feel.



Specs: Sensor type: Optical; DPI: Up to 7,000; Number of buttons: 7



\$89 | WWW.MIONIX.NET

Mionix NAOS 7000

The perfect palm-wrest.

If you're not a palm-gamer, forget this behemoth. It is huge, which is just how palmers love it. As palm gamers, we found this mouse exceedingly comfortable, with room even for our pinky finger to rest on the top of the mouse. When compared to the competition, this thing is huge, so don't even consider it if you're a fingertip or claw gamer. It takes a little while to get used to the size, but once you are, it's arguably the most ergonomic palm mouse on the market.

Due to the shape, it's definitely designed for right-hand gamers, and at its heart is a 7,000dpi IR-LED optical mouse. Mionix claims absolutely zero negative positive or negative acceleration, and we believe them — this thing stayed dead on target, pointing out just how bad our aiming skills were.

Three different levels of DPI settings are available via the slightly complex

software, but changing them couldn't be easier, with perfectly placed DPI switches. There's also a couple of buttons on the left side, for a total of seven programmable buttons, and the entire mouse is coated with four layers of rubber. In other words, it's super comfortable for palm gamers.

We did notice one flaw, though — the scroll wheel felt very sticky to us, nowhere near as smooth as the competition, but that might just be because our sample was brand new.

If you're a palm gamer looking for the ultimate in comfort, we'd recommend giving this a shot, despite the slightly high price.

Verdict

Claw and finger-tip gamers need not apply. Super comfy and worth the price.



Specs: Sensor type: Optical; DPI: Up to 5,000; Number of buttons: 4



\$80 | WWW.RAZERZONE.COM

Razer Abyssus V2

Four buttons? That's it?!

Razer's DeathAdder is one of the most popular gaming mice in the history of, well, gaming mice, but sadly, we couldn't get one in. Instead Razer sent along its new Abyssus v2.

We get it, nearly every mouse on the market now comes with configuration software, but there's one thing we loathe about Razer's — you have to create a user account and remember your username and software to use it. Sure, it's a minor issue, but Razer, please take note — we already have about 400 different usernames and accounts to remember.

The Abyssus v2 itself is a very small mouse, well-suited for small hands, and it's also ambidextrous. This is possible partly because there are absolutely no side-mounted buttons, on either side, making it the only mouse in the roundup to lack these features.

Razer has gone for sheer simplicity with this mouse, which makes that price a tad

hard to swallow. There are just four buttons — the main left and right, a DPI changer and the clickable scroll wheel. It's also one of the lighter mice in the roundup.

The sensor felt excellent, though, with that smoothness we felt with the Logitech, so perhaps some sensors are actually better than the rest, though it's only by the smallest of margins.

Verdict

Small in size and ambidextrous, but lacking in buttons, making its price a little steep.



Specs: Sensor type: Optical; DPI: 2,000 native (up to 4,000 via overdrive); Number of buttons: 6

Specs: Sensor type: Optical; DPI: Up to 4,000; Number of buttons: 6



\$89 | WWW.ROCCAT.ORG



\$49 | WWW.STEELSERIES.COM

Roccat Kiro

Make the mouse you want.

The Kiro's defining features are the removable side plates, which allows it to switch from left- to right-handed mode. There are two spare side plates included, but using these disables two of the four switches found on each side of the mouse (there are two switches on each side). It's also another mouse that appears to be designed for those of us with smaller hands, as it's extremely small and light. However, this makes it more suitable for fingertip and claw gamers, who require a smaller mouse due to their lighter purchase on the surface.

In its default mode, there are plenty of buttons, with a total of seven, including a DPI switcher right next to the scroll wheel. Speaking of which, the scroll wheel is one of the nicest we've felt, with just the right amount of resistance. We're not quite as fond of the software, though, which requires a hefty and lengthy

download for each Roccat device; plus it goes ahead and installs other apps we don't want. At least it saves your settings to the cloud, which can even be accessed via your phone.

Roccat has gone for an all-plastic design; we'd have liked a bit of rubber to make it comfier during long sessions, though this is also prone to sweat.

Once again the sensor feels just right – there really is very little between mice these days to determine their accuracy, apart from the two we mentioned. Considering its configurability, this is one of the few mice that is actually worth close to \$100.

Verdict

A customisable ambidextrous small mouse worth its price tag.



SteelSeries Rival 100

SteelSeries aims at budget gamers — and hits.

SteelSeries is a brand that is better known for its high-end products, but they're taking aim at the sub-\$50 market with the Rival 100. Basically a cut-back version of the Rival 300, it's designed to do the job with the minimum of fuss. If you want customisation options left, right and centre, look elsewhere – the Rival 100 is designed to do one thing and one thing only – let you play games with a great feeling sensor.

Despite the price, it's fully RGB enabled, and even includes things like angle snapping – no sign of mouse mat calibration, though. There's a total of six buttons plus the scroll wheel, and they're all in just the right place, within easy reach.

An optical sensor delivers a DPI up to 4,000, but if there is a flaw, it's that the profiling software can only record two different DPI settings – if you need more, you're outta luck, unfortunately.

SteelSeries also claims zero hardware acceleration, as well as optimised lift-off distance – to us, it felt just right whilst playing games.

Those with huge hands will definitely want to give this a go before reaching for their wallet, as it's quite the small critter, but again, this makes it suitable for all types of mouse grips. Just don't expect it to support your entire hand if you're a palm gamer, unlike the Mionix.

For fifty bucks, it's hard to go wrong with this mouse – it has all of the bases covered, plenty of buttons and a great sensor.

Verdict

For the price, it's great value, and the size makes it suitable for all grip styles.



Specs: Sensor type: Optical; DPI: Up to 6,500; Number of buttons: 6



\$79 | WWW.STEELSERIES.COM

SteelSeries Rival 300

Enough features for the price?

The very first thing we noticed when using this mouse was the superiority of the left and right buttons compared to the Rival 100 – they just felt more responsive and ‘clicky’. Secondly, it’s got a beautiful finish that makes it feel much more comfortable in the hand, with a rubber feel and rubber side plates. It’s also a little more ergonomic (for right-handers only, sadly), with a more contoured shape than the 100. The buttons are also a tad bit larger, making them easier to hit when things get frantic.

However, other than these changes, it’s actually very similar to the 100. It uses an identical optical sensor, although SteelSeries has increased the DPI range to 50–6,500.

If you happen to have a 3D printer handy, there’s a small plate at the rear that can be replaced with a custom logo, which we envisage will be used by

perhaps four people on the planet.

Like the 100, the 300 is limited to just two different DPI settings – we really think three is the minimum these days, especially if you play *Battlefield* (sniping, run and gun, and vehicles). The software is identical to the 100, lacking the mouse pad calibration of others.

If you’re willing to pay \$40 more for these extra features, go right ahead, but in some ways, SteelSeries has delivered a rival product for half the price that is almost as good.

Verdict

While feeling more comfy in hand, we’re unsure if it’s worth \$40 more than the 100.



Specs: Sensor type: Optical; DPI: Up to 12,000; Number of buttons: 8



\$88 | WWW.TTESPORTS.COM

Thermaltake Level 10M Advanced

Yes, this is a mouse.

This is one of the very few mice on the market that still uses a laser-based sensor, giving it a ludicrous top DPI of 16,000. However, the native DPI is actually only 3,200 – Thermaltake uses an overdrive mode to boost it to 16,000. If you can make the most of this, you’re probably using a screen that’s about 12ft across. Despite this, we didn’t notice any jitter or acceleration. But arguably, the most controversial feature of this mouse is its Frankenstein design.

The honeycomb finish on one side allows your palm to breathe while in use, while the height of the rear of the mouse can be adjusted using an included screwdriver.

It’s hard to deny how cool the five-axis thumb stick is, which will come in mighty handy in a variety of games, especially those with spell wheels.

Being a Thermaltake product, it’s obviously festooned in RGB lights, which can all be controlled

via the TT Esports Command software. This also opens up all of the advanced features you’d expect of a mouse of this price. It’s also absolutely plastered with buttons, and has four differing levels of DPI.

And yet, there’s that odd design. Some will love it, others will hate it – we’re really not sure how we feel about it, to be honest. But the inclusion of the five-axis switch is a very nice piece of tech, and many will adore the adjustable height of the palm grip.

Verdict

An odd design but with a cool five-axis thumb stick. If the style appeals to you, it’s worth it.





Keys to the kingdom

Bennett Ring cracks his knuckles and gets tapping to find the best gaming keyboards under \$170.

When it comes to gaming, there's really only one choice of keyboard – a mechanical keyboard. These products use a very different kind of switch behind each key compared to a standard office keyboard, one that is more predictable, faster and easier to tell when it's been actuated. We'll go into more detail about how mechanical keys work compared to other key types later, but there's one slight problem, though – these keys are a lot more expensive than the ones used in basic office keyboards. As you read this article, you'll see that most mechanical gaming keyboards retail for around \$150, which is about twice the price of a decent office keyboard. However, many come with a bunch of other features aimed specifically at gamers, helping to offset this price difference.

Another issue with mechanical keyboards is they're, generally speaking, a lot louder than a normal keyboard. If you're living with a gaming flatmate who uses one, expect to be able to hear each and every key click from at least 10 metres away, which isn't fun if you sleep next door to the gaming den. Thankfully, there are mechanical keyboards that aren't quite as loud, but most gamers choose the louder types.

We're going to explain to you what makes a mechanical keyboard so different to a standard office keyboard, focusing mainly on the switch type behind each key. As mentioned, Cherry MX basically dominates the switches used behind the keys in mechanical keyboards, so we're going to focus especially on their products. There are other mechanical switches now hitting the market, but Cherry has built up such a huge presence that it's become the switch type of choice. We'll also explain other features to look for, such as n-key rollover (which is basically irrelevant these days) and anti-ghosting. Note that we've focused on affordable keyboards, under the \$170 price barrier.

HOW WE TESTED

As most of these keyboards are based on the same Cherry MX keys, their tactile feedback is very similar, depending on the choice of colour. Even those keyboards with non-Cherry keys felt almost identical, as they're basically copies of Cherry keys. We tested with three games – *Battlefield 4*, *World of Warcraft* and *League of Legends*, and found that the difference between each keyboard came down to ergonomics, features, software and price.

TABLE HEADLINE

	MACRO KEYS	NUMPAD	CHERRY MX OPTIONS	RGB LIGHTING	USB PASSTHROUGH	MEDIA CONTROLS
ASUS STRIX TACTIC PRO	13	YES	BLACK, BLUE, BROWN OR RED	YES	NO	YES
COOLER MASTER MASTERKEYS PRO S	NO DEDICATED	NO	BROWN, BLUE OR RED	YES	NO	NO
CORSAIR K70 RAPIDFIRE	NO DEDICATED	NO	SPEED	YES	NO	YES
HYPERX ALLOY FPS	NO DEDICATED	YES	RED	RED ONLY	YES	NO
LOGITECH G213 PRODIGY	NO DEDICATED	YES	N/A - 'MECH-DOME'	YES	NO	YES
LOGITECH G610 ORION	NO DEDICATED	YES	BROWN	WHITE ONLY	NO	YES
ROCCAT SUORA	NO DEDICATED	YES	N/A - TTC BROWN	BLUE ONLY	NO	YES
STEELSERIES APEX M500	NO DEDICATED	YES	RED	BLUE ONLY	NO	NO
THERMALTAKE POSEIDON Z	NO DEDICATED	YES	N/A	RED ONLY	NO	NO

"Red models are the most popular, as they require the least force of all. There's no click, and the motion is extremely smooth, making them very responsive, hence their popularity with gamers."



Set your keyboard up correctly

What the key specs mean and what you might want to change for better performance or comfort.

A standard, affordable keyboard uses a rubber-membrane behind each key. Press the key and the membrane makes contact with a bottom layer, closing an electronic switch which causes the key to activate. However, for this switch to close, the user must push the key all the way down to the bottom. This leads to slower reaction times, not to mention increased fatigues. There's also no feedback — it's hard to tell when you've reached the bottom of the key press. This rubber membrane is why standard keyboards are nice and quiet.

A mechanical switch is very different to the membrane approach. There's a variety of different mechanical

switches on the market, but they all tend to work the same way. Instead of a rubber membrane, every single key has an independent switch. These can be engineered to travel different distances as well as the amount of pressure needed to activate each key — for example, Corsair's new K70 uses Cherry's new MX speed switch, which only needs to travel a mere 1.2mm before registering. Most mechanical keys need around 2mm of travel before they activate, which is why the speed switch claims speed improvements of up to 40%.

Handy features
Mechanical keys also last much longer than membrane keyboards,

at around 50 million clicks versus 10 million for membrane. Most mechanical keyboards also feature n-key rollover, which means that it's possible to hit every key on the board at once, and they'll all register — most membrane keyboards can only handle two or three simultaneous key presses.

Other key features of gaming keyboards include extra keys that can be bound to macros (pre-recorded combinations of key presses), programmable RGB lighting, frameless designs for easy cleaning, and headphone output/microphone inputs. Some also come with a dedicated set of media keys, such as play, pause, volume control and

forwards/backwards.

It's no wonder they cost more than the cheap membrane design used in offices around the world.

Cherry MX switch colours

Cherry makes a variety of different keys, which they separate by colour; Brown, Green, Blue, Red, Clear, Black and Speed. Each one has a different tactile feel and travel distance. Blue switches deliver a click as soon as they're pressed, while Green do the same but require more force. Brown switches tone down the tactile click, with it feeling a bit more like a bump than a loud click, making them a little quieter. Clear switches require less force, but it seems that

the Red models are the most popular, as they require the least force of all. There's no click, and the motion is extremely smooth, making them very responsive, hence their popularity with gamers. Blacks are similar to reds, but require a little more force to activate. Finally, there's the brand new Speed switch, which we mentioned previously.

Confused yet? To be honest, the best way to figure out which key feels best to you is to visit a store that has a variety of mechanical keyboards on offer, and try each of the Cherry MX colours. Our personal favourite is the new Speed switch, followed closely by the Red.



\$115 | WWW.ASUS.COM/AU

ASUS Strix Tactic Pro

A 'board with a plethora of extras.

If you're looking for a keyboard with extras, look no further – this beast has it all. There's a whopping 21 extra macro keys, with a bank of eight on the left, another three under the space bar, while the remaining are normal keys that can double as macros. Recording actions to these is relatively simple using the included software, though the sheer number of them makes remembering what each one does a little tricky. Add to this the ability to record different functions for the macros on different profiles and you're going to need to become a memory master to remember what each one does. We're not complaining, though – having so many macro options is excellent.

ASUS has included four removable bright orange WASD keys for FPS players, while there's a full multimedia control pad above the numpad, with a rolling volume control and the usual playback buttons.

Unfortunately, our sample came with Cherry MX Black keys, which require a lot of force compared to the Speed switches we're accustomed to, but ASUS offers this 'board with four different Cherry options. There's no wrist support included, which can make it a little rough after a few hours of use. It can handle up to 100 keys being pressed simultaneously, though we can't imagine that feature ever being used.

With an excellent price and feature set, this is one of the best value gaming boards on the market. We'd suggest you try the different key types before buying one, though, as switching to Black after using the Speed switch was a finger-straining affair.

Verdict

With macros, multimedia controls and a nice range of Cherry MX options, this is incredible value.



\$154 | WWW.COOLERMASTER.COM

Cooler Master Masterkeys Pro S

Enough features to compete?

To be frank, for \$150, you don't get a whole lot of keyboard with Cooler Master's latest Masterkeys Pro S. We're guessing the S stands for small or slim, as it's one of the smallest keyboards in the roundup, and lacks most of the features that come standard with other keyboards.

Our first issue is the detachable USB cable, which uses microUSB to connect to the keyboard; it's a connection type that isn't renowned for being rugged. Secondly, there isn't a single dedicated macro key on this keyboard – instead, it uses the standard keys to double up as macros. Well, at least it's possible to assign each of these a unique backlight colour, helping to remember which key does what.

There's no numpad, nor any multimedia controls. Likewise with USB pass-through or headphone out/microphone in – this is

one incredibly simple keyboard. Our sample came with Cherry MX Blue keys, though it's also possible to get Brown or Red if you prefer.

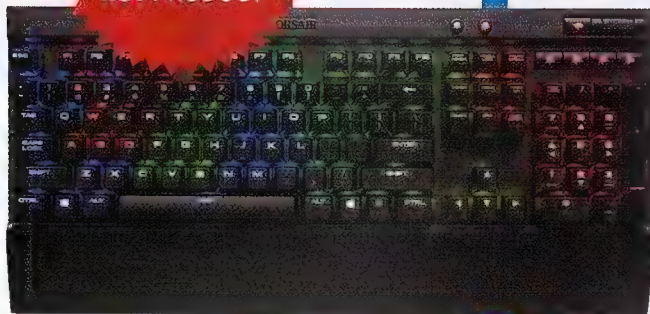
What this keyboard does have though is full RGB lighting, a feature that used to be unique to Corsair but is now as common as daisies. There's no wrist pad, though legs at the rear do allow height adjustment.

We're scratching our heads trying to figure out how Cooler Master can charge so much for so little. Compared to the competition, this keyboard is sadly under-featured and overpriced.

Verdict

There's a stack of competition on the market that offers many more features than this keyboard.





\$159 | WWW.CORSAIR.COM

Corsair K70 Rapidfire

So fast, so good.

Corsair has long had a special relationship with Cherry, getting exclusive access to its latest switches, and the Rapidfire is the latest example. It uses Cherry's new Speed switches, which only require a travel distance of 1.2mm, compared to 2mm for other switches, which enables reaction speeds of up to 40% faster. For this reason it's our gaming and typing board of choice, as it really is noticeably faster than other keyboards.

It takes a little getting used to though, as it's easy to accidentally activate the wrong key, but once you're comfy with it, this thing is a speed demon.

A comfy rubber wrist pad is included, along with full multimedia controls. Unfortunately, it lacks any dedicated macro keys, instead choosing to re-use standard keys if you want macros. Like the Cooler Master board, though,

each key can be bound to a unique colour, making it easy to remember which macro key and profile you're using.

We should point out that it's quite a small keyboard, with no numpad, and it also lacks any USB pass-through or audio jacks. However, it uses a frameless design that makes cleaning out the keys with a can of compressed air incredibly simple, a design that is becoming more common this year. It's also rugged, with an aluminium body ensuring it'll last until the end of time.

Verdict

This is our favourite gaming and typing board on the market.



\$159 | WWW.HYPERXGAMING.COM

HyperX Alloy FPS

Well built, but lacking features.

The new Alloy FPS uses the same frameless design of Cherry's K70.

Basically, this means each key has nothing surrounding it, unlike older keyboards that had a plastic shell around the body. This makes cleaning incredibly simple, and we're sure we're going to see many more keyboards adopt this design in future.

It's a full-sized beast, with numpad, but lacks any dedicated macro keys. In fact, we're not even sure this keyboard can do macros. There's no software, nor any mention of macro recording in the official marketing material. If you're looking for a keyboard that offers a variety of Cherry MX options, too bad – this keyboard only comes with Cherry MX Red. The backlighting is also limited to red, though there are varying shades so you can tone it down.

USB pass-through allows you to connect another USB device directly to the keyboard, but there's no sign of audio inputs or dedicated multimedia controls. Instead, you can control your audio program of choice using the Function keys whilst also pressing the dedicated Function button.

The solid steel frame feels very sturdy, but the lack of a wrist pad is a painful omission for those of us who are used to them. As one of the more expensive boards in the roundup, we expected a little more, but at least it's solid, full-sized and has a frameless design.

Verdict

The lack of macro keys and dedicated media controls makes this an oddity at this price range.





\$99 | EN-AU.LOGITECH.COM

Logitech G213 Prodigy

A strange new sensation.

See that price? That's the difference between using Cherry MX switches and your own custom designed switches. The G213 Prodigy uses Logitech's new proprietary 'Mech-Dome' keys, which require a rather hefty 4mm to activate. It's extremely quiet, and the sensation of each key press can only be described as 'soft'. In-game, there was a perception that actions took just that little bit longer.

The good news is it's waterproof, so when you spill your fizzy drink of choice, your keyboard won't die. Logitech describes the Mech-Dome as a mixture of a membrane and mechanical keyboard, and it certainly takes time to get used to after using mechanical keys for so long. The keyboard is not frameless, so cleaning will be a tedious affair. There's none of the harsh click of a Cherry MX keyboard, which makes it a little trickier to tell when you've actually activated

each key, and yet it's not woefully bad.

This is one of the larger 'boards in the roundup, with full multimedia and numpad controls. It also comes with a non-removable wrist-rest. Logitech has gone for the tried-and-trusted method of using standard keys to double as macros, but we simply couldn't get the software to install, despite trying several times. It's a little odd, as it uses the same software as the mouse, which we managed to install without issue.

Logitech includes eight removable keys to highlight WASD and 1234, just in case you have issues remembering where they are whilst you're kicking some wizard's butt.

Verdict

Try it before you buy it — the keys won't be to everybody's tastes.



\$139 | EN-AU.LOGITECH.COM

Logitech G610 Orion

Back to Cherry again.

Welcome to Logitech's entry-level Cherry MX keyboard. Available with Cherry MX Brown as the only option, you'd better make sure you like this key style before reaching for your back pocket. In many ways, the layout of this keyboard is similar to the G213, with most of the keys in the same place.

Rather than full RGB lighting, this board only offers white backlighting, but it can be set to individual keys. For example, if you only want WASD lit up, then you can do so. There are zero dedicated macro keys, instead doubling up the functionality of existing Function keys, for a total of 12. There are full media controls, though, not to mention a numpad on the right — this feature is crucial for certain gamers (and certain games).

Given Logitech's excellent reputation for

ergonomics, we were a little surprised at the lack of a wrist pad. On the other hand, the rear feet that can be used to adjust the height of the board have three positions, rather than the on/off of other keyboards.

There's also no USB-passthrough or audio inputs, both features which seem to be lacking at this price point.

Once again, we couldn't get the Logitech software to install, which seems to be a bug after uninstalling it several days prior during our mouse test.

Verdict

This isn't a bad keyboard — there's just plenty of competition that offers better features at this price.





\$159 | WWW.ROCCAT.ORG

Roccat Suora

A bit light on features and value.

Roccat was one of the first companies to introduce the frameless design we're now seeing take over, which probably explains the price on this board. It's also built to the exacting specifications that Roccat takes pride in, which also goes some way to it being one of the most expensive keyboards here.

Despite the relatively high price tag, this keyboard doesn't actually use Cherry switches. Instead it uses TTC Brown, which feel almost identical to Cherry MX Browns and are rated for 50 million strokes. Given the cheaper price of these keys, we're not too impressed with the \$159 price slapped onto this keyboard.

Roccat has ditched full RGB lighting for a plain blue lighting effect instead. Various effects can be programmed via the Swarm software,

which unfortunately also downloads a bunch of other stuff in the process and requires several updates before it works properly.

Forget dedicated macro keys, but at least there's a bank of media keys above the numpad. However, up to six of the normal keys can be used as macros, once you've installed all of the necessary software.

Roccat claims the lack of a wrist-rest is actually a bonus, but we beg to differ, especially after several hours of use. Built on an aluminium frame, it's nice and tough, but for the price we expected a whole lot more.

Verdict

Despite lacking advanced features, Roccat thinks it can charge one of the highest prices on the market.



\$145 | WWW.STEELSERIES.COM

SteelSeries Apex M500

Blinding LEDs, blinding price.

In case you hadn't noticed by now, the vast majority of keyboards in the mid-range sit around the \$150 price point, and the Apex M500 is no exception. Yet with keyboards like the Asus Strix Tactic Pro offering so many features at just \$115, competition is tight indeed. It takes more than mere Cherry keys and basic macro recording to stand out – and sadly the Apex M500 doesn't have much more to offer.

Available with just one Cherry MX option, Red, the first thing we noticed about this keyboard is how bright the blue backlights are. This thing will light up your gaming den until you tone it down a little (if you can see afterwards).

Key placement is excellent, though, with everything just in reach without having to move your hands, including the delete and tab/caps keys.

According to SteelSeries, this keyboard is "built like a tank". Sadly, we have to disagree – heavy plastic just doesn't compete with aluminium or steel.

Each and every key on the board can be assigned various duties via the SteelSeries Engine software, but there's not a dedicated macro key in sight. There's not even any dedicated media controls, which is a bit of an oversight at this price level. Ditto with any form of audio inputs or USB passthroughs, and the lack of a wrist-rest doesn't sit well with us after loving the K70's lovely rubber wrist-home for so long.

Verdict

A \$150 keyboard that fails to compete, lacking many of the features that should be standard.





#89 | TTSPORTS.COM

Thermaltake Poseidon Z RGB

You won't find cheaper.

As the most affordable board in our roundup, the Poseidon Z offers many of the features found on other \$150 keyboards, minus Cherry keys. Instead, like the Roccat, it uses TTC switches, which are almost identical, if not quite as precise. Our sample came with the TTC Brown, which is a little soft for our liking, making response times in games a bit slower than we prefer. However, this really is a matter of preference – many gamers prefer the less clicky, softer feel of these compared to the Cherry MX Reds that are so popular.

While there aren't any dedicated macro keys, Thermaltake has chosen the popular path of reusing existing keys as macros, programmed by the Poseidon Z RGB software. Up to five different profiles can be recorded for your

favourite five games, and the fact that it's also fully RGB, covering over 16 million colours if you so desire, means you can assign certain colours to certain macros, a handy feature. It uses a standard key layout, so everything is easy to find, but once again, we find the lack of a wrist-rest a strange omission – don't these companies read anything about ergonomics?

Still, for the price, this is a compelling option. It's got most of the basics covered by keyboards that are \$50 more expensive, yet still comes up short against ASUS' amazing Strix board.

Verdict

We'd recommend trying out the TTC switches that come with this board before purchasing.



SteelSeries speaks

We grill the PC peripherals company about mechanical switches.

SteelSeries were one of the first manufacturers to make mechanical keyboards. We caught up with the company's Jason Christian Snr (Product Manager — Keyboards & Mice) to get some insight on why everybody loves Cherry, what separates all of these keyboards that use the same switches, and how the new wave of mechanical switches compete.

APC: What are the main differences between rival keyboards that all use the same Cherry MX switches?

JC: The German company Cherry is known worldwide by gamers as making the highest quality switches. SteelSeries uses the Cherry MX Red switches, the fastest switch, in our Apex M500 gaming keyboard. Within the keyboard category you have a wide range of different options. From Size, and what type of LED's that are being used. Single colour LED and RGB led are by far the most popular. When looking at the rival keyboards a few factors come into play. How is the durability? Is easy-to-use and intuitive software provided? It is has never been a better time to be a gamer right now. The performance aspect of using a Cherry MX mechanical keyboard cannot be replicated.

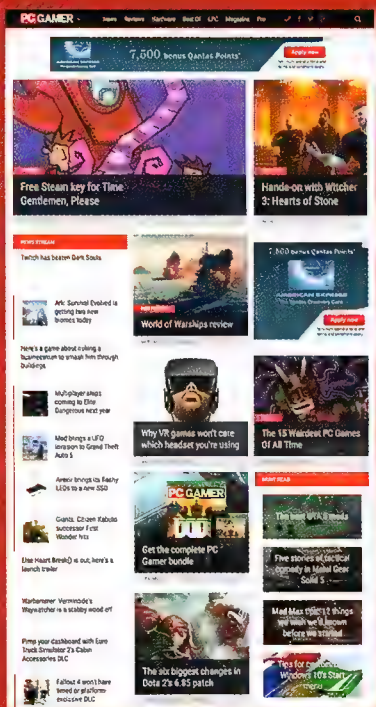
APC: Which Cherry MX colour is most popular? Any idea why?

JC: The most popular colour of Cherry switch are the Reds. MX Reds are the fastest switch that Cherry manufactures. They required only 45g of force to register a key stroke. They've been proclaimed by the community as 'the gaming switch'. Other popular switches are MX Blues and MX Browns. Different regions of the world do have different preferences. MX Reds are also the best switch for someone to use that may be coming from a membrane keyboard. The smooth travel provides great feel and you can really feel the difference.

APC: How do you think the non-Cherry Mechanical switches compare to real Cherry MX switches?

JC: I have personally had the opportunity to travel to Germany and visit where Cherry produces the switches. All the individual components of the switch are sourced from all over Germany, Germany engineering at its best. Most people do not realise Cherry is a part of a larger company called ZF. Literally feet away from where the switches are being made, you see high-end electronic equipment being produce for the world's top super cars. Cherry has been making switches for over 30 years and leave it down to an art. When compared to other switch manufactures Cherry really shines. Cherry has the best industry rating of its MX switches. I have personally seen data shows from the first press to over 100 million presses, the quality is nearly the same.

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Loud and clear

The APC team tests eight pairs of gaming headsets that'll let you hear the action loud and clear — and even be heard over all that din, too.

While we'd all love to be able to plug in a monstrous surround-sound audio system into our gaming rigs, for most of us, the reality is that a headset is far more practical... and a lot less disruptive to the other people we live with.

As with gaming keyboards and mice, the market has become absolutely flooded with headsets over the last few years — everyone wants a slice of the still-relatively-healthy PC gaming space. There's been a rather positive outcome to that glut, however, in that, unlike a decade ago, not all of them are garish-looking, overly-bassy abominations. There are some genuinely classy sets amongst those we tested — and (not coincidentally, we're sure) they're often the best-sounding ones too.

This month, we've reviewed headsets from as many major brands as possible, allowing vendors to submit just one set each. We received products at a variety of pricepoints, ranging from under \$100 right up to \$350... and we should point out that they're not even the most expensive ones on the market. Venture into high-end wireless territory and you'll find that prices skyrocket — we'll take a dedicated look at the wireless category in a separate feature a bit further down the track.

HOW WE TESTED

If you've been reading APC for any length of time, you'll know that, in every round-up, we let you know how we tested the gear. Usually this just involves a little annotation below our benchmarks table, listing what hardware we used and what tests we ran. However, we've already established that audio is an entirely different beast. We could look at base specifications for each headset, but in all honesty, that really doesn't tell you much, and the true nature of audio lies in the listener experience — how the sound feels.

That said, we wanted to ensure we had a fair and balanced test bed for this roundup, so we decided on the following. Firstly, we connected every set via analog only — we wanted to ensure that no single company or manufacturer had any unfair advantage thanks to embedded soundcards, USB connections or other such tomfoolery.

In terms of audio testing, we listened to a variety of music from different musical genres, largely by streaming lossless FLAC 1,411kbps files from Tidal. Then it was straight into games, with a combination of modern titles including *Star Citizen*, *Project Cars* and *Call of Duty: Black Ops III* to gauge how exactly the headphones responded and felt under the different gaming genres. Ultimately, we're looking at three different categories: comfort, style and, most importantly, overall soundscape.



\$349 | WWW.AUDIO-TECHNICA.COM.AU

Audio-Technica ATH-AG1X

Damn, that's comfortable.

Audio-Technica's AG1Xs are by far the comfiest headphones we've ever tried, despite the lack of manoeuvrability. The two pads located at the top rest on your head gently and adjust to the fit and shape of your cranium, ensuring the least pressure is placed on top of your skull, reducing the overall weight.

Despite being a closed back design, the AG1Xs have a wonderfully airy feeling to them. AT's DADS system ensures that there's a thick layer of air surrounding the driver, and it's noticeable.

They sounded impressive. They're bass-heavy, thanks to their gaming heritage and design, but without overpowering the treble. Metal, rock and punk all sounded glorious. Classical music did suffer a bit. Bass-heavy tracks love these things.

In-game, the AG1Xs were stunning. You can hear the punch of the explosion and the crackle of the sparks.

The AG1Xs do convey a certain pleasant warmth, too — a somewhat earthy vibe. Ultimately, these little beauties are just really fun to listen to. If you're after perfect sound replication, you might want to opt for some reference studio headphones, but if you just want to enjoy your music, the AG1Xs are the ticket. If it wasn't for the price, these would sell like hotcakes. The sound quality is stunning, they're beyond comfortable, and the oddly open/closed air design is joyous on the lugs. They don't hug you, yet they isolate noise perfectly.

Some of the mid is a little less crisp than we would have liked, but that's an absolutely minor detail in reality.

Verdict

A great design and comfortable, with stunning gaming sounds and solid music. But pricey.



\$90 | WWW.CORSAIR.COM

Corsair Void Stereo

Budget audio but not without sin.

At this price, the Void Stereo is bound to come with some caveats, although we didn't expect quite the degree of plastic and soft fabric that besieged us. However, if it weren't for Kingston offering up the HyperX Cloud IIs, featuring an aluminium and leather design for \$10 more, we wouldn't even question it.

The drivers do sound quite flat, unfortunately, and a general muddiness shone through under heavy bass, while the treble and high mids suffered from a lack of depth. They were average at best. Instrumental music suffered the most, feeling deflated, with less bite, and empty, as though each song had been recorded while the microphone was muffled by a pillow. There just wasn't enough in the mids. The bass was certainly prominent, but it couldn't make up for the lack of overall soundscape.

For synthetic dubstep and heavier genres that don't

rely on the rising clash of string instruments and treble-based percussion, the Voids sounded good. Gaming was enjoyable, too — in fact, the Voids excelled in this area. But here inherently lies the problem. You have to want these just for gaming and nothing else. For accurate, deep, acoustical representation, they just fall flat on their face, and that saddens us greatly. After all, none of us really game 100% of the time.

Overall, they're still fairly comfortable, and provide a pretty average soundscape.

For the price, we would have liked to have seen a better frequency response (maybe to catch some of that missing treble), and use of more premium build materials.

Verdict

Comfortable, affordable, good for gaming, but has a flat soundscape and low frequency response.





\$145 | AU.CREATIVE.COM

Creative Sound BlasterX H5

Sound, thy name is mud.

The Sound BlasterX H5 is one of the comfiest gaming headsets we've ever had the pleasure of using. The satisfaction you get as it fits around your lugs is second only to Audio-Technica's newest AG1X. It's not heavy, nor bulky. It just sits right. If only we could stop here.

Right out of the gate, the H5s are incredibly muddy. There's an unbelievable degree of emptiness in the mids and treble. Although the bass is prominent, the overall sound structure is very limited — they just couldn't compete in contrast to any of the other headsets in this group test for crystal-clear audio reproduction.

Connecting an external DAC like Creative's own Sound Blaster X7, which we had on hand for testing, will get you far more prominent bass — dubstep, heavy metal, and punk were better, but the clarity needed for instrumental and classical scores just wasn't there.

Gaming, on the other hand, was good fun. This will entirely depend on what games you like playing, of course, but if you enjoy music as much as your games, you might want to take a step back here and opt for something else.

For the price, we'd have loved to have seen a better soundscape. It can be countered somewhat with a dependable DAC or soundcard, but if you're investing that kind of money, you'd probably want to drop some cash into a better pair of headphones anyway.

The H5s are comfortable and light. Ergonomically, they're strong contenders, but alas, that's just nowhere near as important as solid audio quality.

Verdict

Comfortable, strong bass, good connectivity, but expensive, with awful treble/mids.



\$130 | WWW.HYPERXGAMING.COM

HyperX Cloud Revolver

Return of the king?

Let's cut to the chase — if you're after the best bang for your buck, there's little doubt that HyperX Cloud headsets are monstrously good value for money. With an incredibly wide soundscape, great comfort, and options for both 3.5mm and USB connections, you'd be hard pushed to find anything better for the price.

The Revolvers are incredibly comfortable. The intuitively-designed headband relieves pressure from the top of the head, and requires absolutely minimal adjustment. Despite their appearance, they're actually open-backed, with small air intake holes hidden behind that extruded logo. That opens up the air around the drivers, providing a better sound for the listener, yet without suffering from a huge amount of sound leakage. You also get an impeccably good removable microphone, which adjusts easily and holds its form impressively well.

Acoustically, they have an incredible range, with powerful bass, which did, unfortunately, muffle some of the smoother tones you get in acoustic music. Metal, punk and synthetic tracks all sounded great.

In game, the Revolvers were sharp, with a soundscape that was particularly great in FPSs.

What about compared to the old Cloud II model, though? Well, the Revolvers definitely had the edge when it came to treble — the soundscape was deeper because of it, yet not enough to pull it out too far in front.

The Revolvers have that gaming flair about them, too, which isn't going to be for everyone.

Verdict

Great soundscape, comfortable, with removable mic, but pricier than Cloud IIs with no USB adapter.





\$225 | WWW.GAMING.LOGITECH.COM

Logitech G933

We heard you like connectivity.

The G933s are huge. They're comfy, but by god, are they big! On top of that, they're a little too flexible. Thanks to that rather skinny headband, and an overall plastic build, the fear of snapping them is all too real.

Plugged in via a 3.5mm jack only, and ensuring the headset is switched off (turning the headset on enables an audio equaliser inside the drivers), brings us in line with exactly what we would expect a gaming headset with these kind of specs to sound like. With the equaliser switched off, the G933s are incredibly bass-heavy, but the mids are a little damp, and the overall height of the treble feels a bit reduced. Unless, of course, you switch on the headset, in which case they were just a little subpar.

That said, it was still an enjoyable experience listening to metal or heavier music genres – however, they did have a habit of losing the crispness on the

top end. Gaming was good fun as well. The bass was heavy, and the necessary treble and mids required to provide a rich soundscape shone through just enough to illuminate the gunshots, laser fire, and explosions in *Star Citizen*.

Ultimately, the G933 Artemis Spectrum is not meant to be used this way. It's a wireless headset – at worst, USB.

With the headset switched on, there's plenty of audio balancing going on internally to ensure a solid soundscape. But for the price, you're limited by it, and you still have to plug them into a DAC to get anywhere near as good a sound quality as some of the other units we tested.

Verdict

Great connectivity, onboard balancing and comfortable, but fragile and pricey.



\$149 | WWW.PLANTRONICS.COM/AU

Plantronics RIG 600

Solid sound and cracking comms.

Compared to the choose-your-own earpad function and configurable fit of Plantronics' 500-series gaming gear, the high fidelity 600 is as basic and minimal as it gets.

This slick-looking headset is crafted from durable matte plastics, skinned in synthetics and neoprene for the contact areas. They're gentle on the skin and the cans are plush enough to cushion even the knobliest of noodles.

Sonically, the 40mm drivers pack a lot of punch – there's a load of solid low-end in there and consistent mids, though the highs were a little iffy at times depending on the source. Where the 600 is great is in game and mobile communication; with crystal clear, non-breathy comms resulting from testing over multiple voice apps and mobile.

Touted as isolating and immersive, we actually found the 600 to be anything but, with external

noise leaking in, and worse, game sounds and music leaking out like the proverbial sieve.

There are two cables included in the box; one with a built-in boom mic for use with your consoles or PC (there's a mic/audio splitter cable bundled in too) and another with an in-line mic for taking the 600 on the road with your mobile. While both options feature in-line controls, the latter, frustratingly, doesn't have a volume toggle – so be prepared to dig into your backpack or pocket when you want to turn that s–t up. One simple design feature we did love was how the cable plugs into the rear of the left can, which keeps it running close to the body and largely tangle-free.

Verdict

A gaming headset with the only features you really need; great sound and even better comms.





\$240 | EN-AU.SENNHEISER.COM

Sennheiser Game One

Could these possibly be the new kings of gaming audio?

The Game One's small design doesn't compromise on comfort. It looks flash, and although made primarily with sand-blasted plastic, the One feels sturdy and secure. The open-backed design makes it airy.

And they're surprisingly well rounded when it comes to audio. The sound signature is really sharp. There's absolutely zero mid smothering, and the treble remains sound and true. Bass is definitely there, but it's reassuring, as opposed to vibrating your head off. One problem we can spot is there does seem to be a cut-off on the treble; some of the more audiophile offerings actually provide far crisper trebles, especially at the high end for strings and percussion.

We connected Creative's X7 DAC and found it made the Game Ones a bit more punchy in the bass department, yet still not too overpowering on mids. These cans just have a really

well-rounded soundscape, and it makes them a pleasure to listen to. As far as gaming goes, they do suffer a bit without the extra bass found in most gaming headsets, but if you tweak the EQ just a little, you'll have more than enough power.

Ultimately, these are a great pair of cans. They're nicely priced, and they're solid for gaming. The crisp, clean soundscape lends itself to those who are looking for almost audiophile-quality drivers without giving up that microphone.

That said, they do feel like a very niche product, for someone who's part gamer and part almost-audiophile.

Verdict

Crystal-clear soundscape with a good price, good design and strong microphone.



\$95 | STEELSERIES.COM

SteelSeries Siberia 200

Stylish, lightweight and affordable.

The Siberia 200 has a great design, and its lightweight plastic nature means you'll soon forget they're on your head... provided it's of a reasonable size. The headband incorporates an expanding bridge design, which rather limits the head size these 'phones are suitable for.

The wires holding the headband in place felt a little flimsy, too, making us wonder how long they'll last travelling in a backpack between LAN events. Plus, the inside circumference of the cups seems too small for the average ear to sit comfortably, meaning the cups' material will be pressing against your upper and lower lobes.

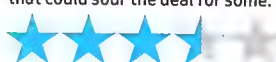
While the SteelSeries Siberia 200 claims to have found the ultimate balance of audio for competitive gaming – enabling you to both hear enemy footsteps and distant explosions – it's not quite the perfect balance we were hoping for. We found the bass to be a

little withdrawn, meaning that Korn's *Somebody* *Someone* didn't pack the punch it should. True, the 200s aren't meant to be on par with audiophile-quality headphones, but the fact that they're compatible with mobiles means those who want to use these for audio listening as well might be a little disappointed. Despite this, the sound is crisp and clear on the whole, so if you don't care much for throbbing bass, you may be able to overlook this particular niggle.

The retractable and unidirectional mic is intelligently hidden away into the left cup when not in use – our favourite feature, great for the overall design and also to keep it safe while on the move.

Verdict

Great design and good sound quality, but with a couple of flaws that could sour the deal for some.



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Escape Windows to Linux

Had enough of Windows? Make the switch to Linux and discover the power and freedom it offers.

Nick Peers flings open the escape hatch.

The launch of Windows 10 is a great opportunity for those frustrated with the Microsoft ecosystem to find a better way. And what better way than Linux? If you've just bought a PC with Windows 10 pre-installed or upgraded from an earlier version and decided enough's enough, or have a family member or friend who's finally seen the light, this feature is for you.

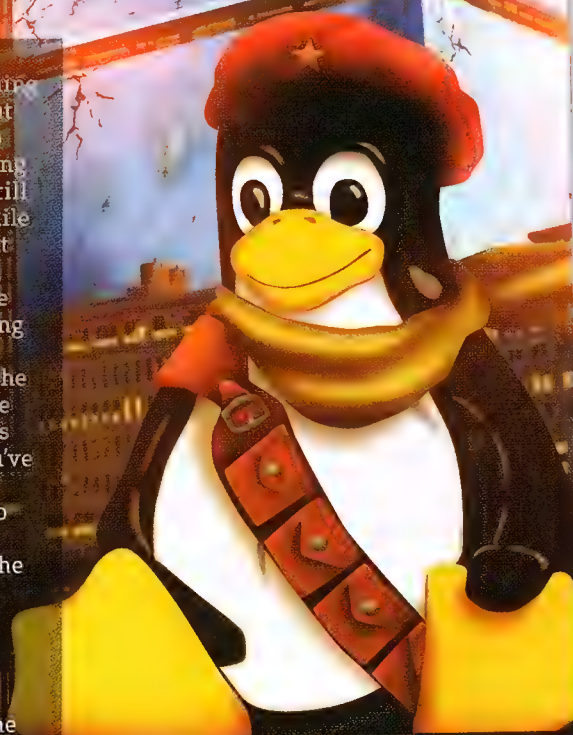
The easiest way to migrate from Windows is through Mint, a user-friendly Linux distribution (distro) that's packed with all the features you need, wrapped up in an accessible user interface particularly suited to first-time switchers. You'll find the latest version – Linux Mint 17.3 32- & 64-bit – here: tinyurl.com/apc435-mint. We'll be using that version to step you through the process, but most of the guide can easily be adapted to Ubuntu (either 15.10 or 14.04.3 LTS) if you'd prefer.

The process is straightforward: first, you'll back up your hard drive in its current state, so you know you

can always roll back to the beginning of the process if necessary without data loss. Then we'll reveal how to install Mint alongside your existing Windows 10 installation, so you still have access to your old system while you make the transition. We'll sort out any dual-boot issues you have, plus expose the truth behind some myths that put people off switching in the first place.

We'll also take you on a tour of the new Cinnamon desktop, reveal the basics you need to get started, plus show you how to switch to it if you've installed Ubuntu. Last, but by no means least, we'll show you how to install apps on your new system, find open-source alternatives to the key programs you've been using previously and even reveal how to get some Windows programs running with the help of a clever tool called Wine.

Everything you need to make the switch is here, so now there's no excuse. Read on to discover how to escape Windows 10 and transform your computing experience.



"The easiest way to migrate from Windows is through Mint, a user-friendly Linux distro."

Get backed up

DON'T EVEN THINK ABOUT INSTALLING LINUX UNTIL YOU'RE BACKED UP.

There's nothing worse than attempting to upgrade or install a new operating system only for something to go wrong. You can replace that gut-clenching feeling with one of minor irritation by making sure you've backed up your Windows installation (or just your data) before you begin, this will enable you to easily roll back to a working state if something goes awry.

There are numerous backup tools for the job, but we've plumped for Redo Backup and Recovery, which works beautifully with both Windows and Linux installations – go to www.redobackup.org/download.php and follow the instructions to download the Redo Backup live CD in ISO format. Burning it to disc is simple: pop a blank disc in the drive, browse to the ISO file in Windows 10, right-click it and choose 'Burn disc image'. If you'd rather create a bootable USB stick, make sure it's been formatted as FAT32, then download and run the latest version of Unetbootin from sourceforge.net/projects/unetbootin – select the Diskimage option, click '...' to select your ISO file and verify the correct USB drive has been selected before clicking 'OK'.

Before proceeding further, you should also create a Windows recovery disc or flash drive if you don't already have Windows 10 installation media – you may need this should you run into problems with dual-booting Ubuntu

and Windows. Type 'recovery' into the Windows 10 Search bar and choose 'Create a recovery drive' to get started.

Once your recovery and Redo Backup media has been created, reboot your PC with the Redo Backup drive inserted, then tap the option at startup to select your boot device (often F11 or F12). Select the drive and then choose 'Start Redo Backup' when prompted. If you end up back at the boot choice menu, then it's likely you're trying to boot from a newer PC in UEFI rather than BIOS mode (see the 'Roll back and Start Again' section, below for help resolving this issue). If you're unable to get Redo Backup working in any shape or form, try backing up using the built-in Windows disk imaging tool instead, which is part of the Backup and Restore tool.

BACK UP WITH REDO

When the main screen appears, click the 'Backup' button to get started. Select the drive Windows is currently installed on (typically drive 1) from the drop-down menu and click 'Next'. All of the drive's partitions will be selected – leave this as it is and click 'Next' again.

Next, you'll be prompted to choose your backup destination – typically the largest partition on an external hard drive directly plugged into your PC, so select it from the list, making sure there's adequate backup space

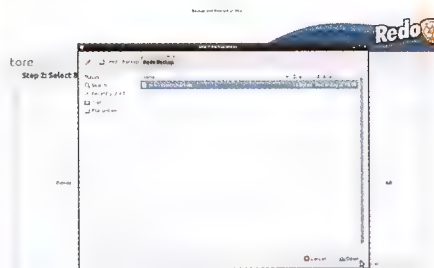
available, and click 'Next' again. Once done, click 'Browse' to select or create a folder inside which your backup will be stored. Click 'Save Here' followed by 'Next'. Give your backup a suitable name – the default date is a little confusing, so feel free to change it to something like 'pre-Mint'. Click 'Next' again, then sit back and wait while Redo Backup does the hard work of backing up your drive. This can take some time, so if you have another PC handy, why not use the time to prepare your Mint install media following the advice over the page? Once that's done, and the backup completes successfully, you're ready to install Linux.

If something goes wrong with your Mint installation, or you want to start again from scratch and try a different approach, then all you need to do is boot from your Redo Backup media and follow the step-by-step guide below, which should put things back exactly the way they were before you started.

QUICK TIP Live disc

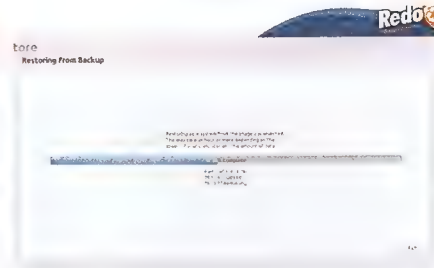
A cool trick that Linux distros can pull is to enable you to run an entire Linux OS directly from a DVD called a Live Disc. This means you can test out the distro without installing at all.

Roll back and start again



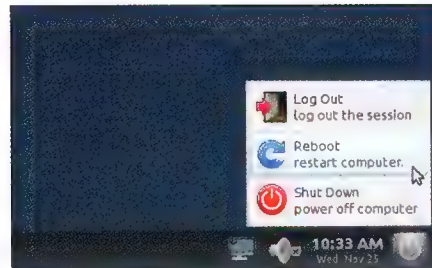
1 BOOT AND SELECT BACKUP

Boot from your Redo Backup CD or flash drive, clicking 'Start Redo Backup' when prompted. When the main screen appears, click the 'Restore' button. First, select the partition on the physical disk your backup is stored on, then click 'Next'. Click the box to open the Select Backup Image dialog, then browse to the folder you placed your backup in, select the backup job file and click 'Open'.



2 RESTORE PC

Click 'Next', then select the drive that contains your Windows installation. The entire drive will be overwritten with your backup, so read and digest the warning before clicking 'OK'. Wait while the drive is restored to the state it was in when you took the backup. As with the backup process, this can take some time, so be prepared for a long wait.



3 BOOT AND START AGAIN

Once the process completes, click 'OK' followed by 'Exit'. Click the power button in the bottom right-hand corner and choose 'Reboot'. Remove the Redo Backup boot media when prompted and press 'Enter'. Your system will reboot and you should find Windows loads as it did previously. You can restart the installation process now to correct a previous mistake.

Install Linux Mint

PREPARATIONS ARE COMPLETE, IT'S TIME TO GET MINT INSTALLED

With your fail-safe backup in place, you're now ready to take the plunge and install Linux Mint. The following procedure assumes you want to install it alongside your existing Windows installation — it's a good route to follow for first-time switchers, as well as for those helping others to make the migration to Linux.

Like all versions of Mint, it's a Long Term Support (LTS) release, with support guaranteed until April 2019. If you'd rather try Ubuntu, go to www.ubuntu.com and select 'Download'. Click 'Ubuntu Desktop' and download the correct version for your processor (64-bit in most cases) of either Ubuntu 14.04.3 LTS or for the latest release, 15.10. Creating your Mint or Ubuntu install disc or flash drive is the same process for Redo Backup (on the previous page) and the installation process is identical for both Mint and Ubuntu.

When your PC boots, it makes use of a tiny piece of software to get itself up and running. In the past, this was known as the BIOS (Basic Input Output System), but it's been superseded by the more powerful and flexible UEFI (Unified Extensible Firmware Interface). In practical terms, the UEFI offers a more user-friendly interface and better features, but it's not compatible with older hardware.

Most UEFI systems ship with a special Compatibility Support Module (CSM), which allows you to emulate the BIOS when attempting to use older hardware and operating systems. They also ship with Secure Boot

enabled, a special feature designed to protect PCs from low-level malware.

Your PC will almost certainly have Secure Boot enabled, which isn't a problem for Mint, which fully supports it. However, another new feature — FastBoot (also called QuickBoot or FastStartup) — will almost certainly be enabled too, and this needs to be disabled before you can install Linux. (See the 'Fix UEFI Boot Issues' box, below, for how to do this.)

Once you've edited your UEFI's settings, make sure your installation media is plugged in, then reboot your PC. Look for an option to access the boot menu when you start — typically a key like F11. This will bring up a list of available drives: select your DVD or USB flash drive and hit Enter.

Don't panic if you see two entries — this happens when CSM has been enabled, with the non-UEFI option allowing you to boot using the older BIOS compatibility mode. However, Windows 10 will almost certainly have been installed using UEFI mode, so select that option to continue.

PARTITION YOUR DRIVE

When you arrive at the Mint desktop, double-click the 'Install Linux Mint' icon. Verify English is selected, click 'Continue' and then verify both boxes are checked before clicking 'Continue' again. Wait while the installer scans your hard drives. In a perfect world, it should spot your Windows 10 install, but this isn't always the case. If it claims there's no Windows installation, the simplest thing to do is follow the

step-by-step guide (see the 'Manually Configure your Drive for Dual-Booting' section on the next page) to set up your hard drive manually.

If the installer does detect Windows 10, leave 'Install Linux Mint alongside Windows 10' selected and click 'Next'. Your next step will be to hive off enough drive space to give Mint the room it needs. The installer will make a calculated guess, but you can click and drag the divider between the two to set this figure yourself. Note that if you have more than one hard drive, Mint may actually choose a different drive to install itself on, so verify which one it's picked and click the drop-down arrow next to 'Select drive:' to see if you can change this if necessary. If you can't, and you don't want to install it on the recommended drive, click 'Back' and follow the step-by-step guide to do things manually.

Assuming Mint chooses the same drive as Windows 10 to install itself on, leave at least 10GB free space for Windows, and give Mint a minimum of 8GB drive space to work with — more if you plan to make it your primary OS. Remember that you can always repartition the drive later or remove

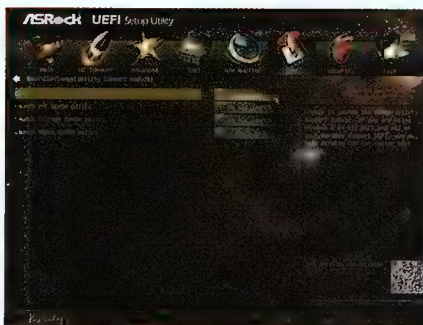
QUICK TIP Full install

Mint and Ubuntu will offer to live beside Windows in total harmony, but they can also wipe out Windows for the full Linux experience.

Fix UEFI boot issues

Switch on your PC and tap the key prompted to enter setup — usually Del or F2. Look for the FastBoot setting under Boot or Windows Configuration, then make sure it's set to disabled. If you have problems getting Redo Backup to launch, you should also temporarily disable Secure Boot and potentially tweak the CSM settings in order for Redo Backup to work correctly — look under Boot, Security or Windows Configuration for these settings.

When it comes to CSM, its settings may be hidden away in their own menu, where you'll find references to the likes of PXE (pre-boot environment), GOP



Tweak your PC's CSM settings if necessary to get Redo Backup and Recovery working properly if it's a newer model.

(graphics) and Storage (or SATA), as well as USB and PS2 if applicable. This allows you to selectively switch CSM on and off for

specific devices as required. If there's an option to run both — as is the case with some ASRock motherboards, select the appropriate option (such as 'Do not launch') to ensure maximum compatibility and performance.

Not all PCs, particularly off-the-shelf models, will give you access to all of these settings — contact the manufacturer to query where these are, or ask about an update that brings them back. Also search for your PC's model and manufacturer and the words 'CSM', 'UEFI', 'Linux' or 'Mint' to see if there's a precedence set by other switchers you can follow to get the settings you need enabled.

the Windows partition. Once you've set up the drive, click 'Install Now'. Make a note of the warning and click 'Continue'.

You'll be asked to confirm the proposed changes — by default, the Mint installer creates just two partitions (the Ext4 entry is your Linux partition, plus it creates a dedicated swap partition). Click 'Continue' to accept the change.

Next, the installer will attempt to detect your location, settling on your closest main city, in most cases. You can accept this or type the name of your nearest large town to see if it's

recognised. Click 'Continue', then set your keyboard layout.

The next stage is where you first type your name — you'll see the computer name is pre-filled for you along with your username as you type. You can change these and enter a password — you'll need to provide this when you log in, plus an administrator's password for performing certain tasks.

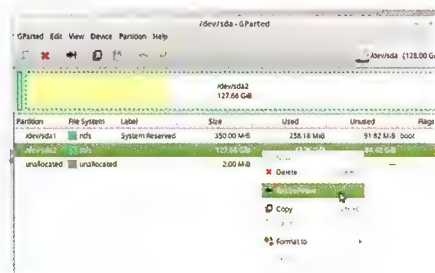
Only opt to log in automatically if your PC isn't shared, and if you're installing Ubuntu on a laptop, tick 'Encrypt my home folder' to protect your data should you lose it. Click

'Continue' and you're done — Mint will install itself in the background.

You can go off and make an APC standard cup of tea (or two) while you wait or sit and read some highlights about what features and applications are included in Ubuntu, and how to find more using the Software Center.

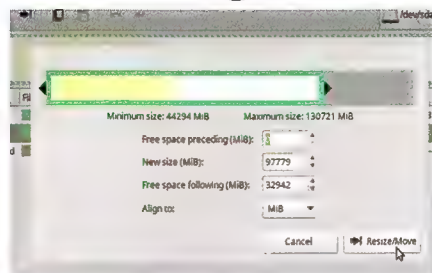
When installation finishes, click 'Restart Now', remove the installation disc or drive when prompted, and hit 'Enter'. Ubuntu is now installed — turn the page to find out how to start using it.

Manually configure your drive for dual-booting



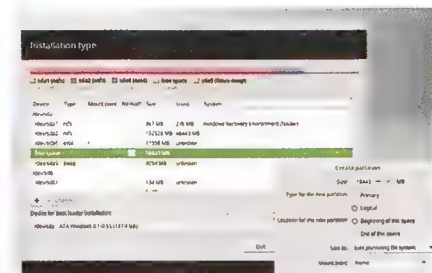
1 LAUNCH GPARTED

Boot your Mint install media. When the desktop appears, click the 'Menu' button in the bottom left-hand corner and in the Search box type 'GParted'. Click the GParted entry when it appears to launch it. Verify your Windows drive is selected (/dev/sda) — you should see at least two partitions, the largest of which is your Windows partition. Right-click this and choose Resize/Move.



2 FREE UP SPACE FOR LINUX

Click on the right-hand slider and drag it left to free up enough space for your Ubuntu install — leave at least 10GB free space for Windows. Once done, click 'Resize/Move' followed by the 'Apply all operations' button, selecting 'Apply' when prompted. Wait for the partitioning to complete, then click 'Close'. Double-click the 'Install Linux Mint' shortcut. Select 'English' and click 'Continue'.

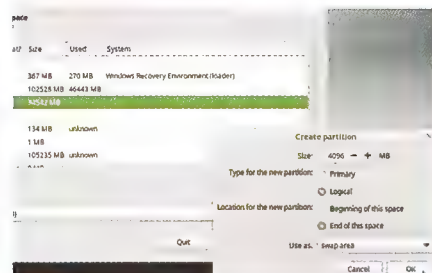


4 SET UP LINUX PARTITION

Select the free space and click the '+' button again. This time, set the partition size to 12,000MB (12GB), leave 'Logical', 'Beginning of this space' and 'Ext4 journaling file system' selected. Click the 'Mount point:' drop-down menu and choose '/' to make it the main partition for Ubuntu to reside on (if you have plenty of free space, make it bigger). Click 'OK' again.

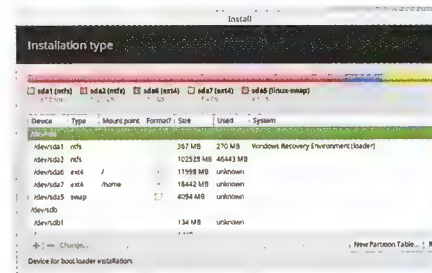
5 CREATE HOME PARTITION

Select the remaining free space and click '+' again. Leave everything as it is, except the mount point, which you should point to /home before clicking 'OK'. The /home directory is where everyone's personal files and settings — including documents, pictures and programs — are stored, so make sure it's the biggest partition of the three. Once done, review your changes.



3 START PARTITIONING

Leave both boxes ticked and click 'Continue'. Select 'Something else' under 'Installation type' and click 'Continue'. Select the free space under /dev/sda and click the '+' button to set up your first partition. Set the size to 4,096MB, leave 'Logical' selected for the partition type, but select 'End of this space'. Click the 'Use as:' drop-down menu and choose 'swap area' and click 'OK'.



6 SET BOOT PARTITION

If you need to set up your partitions again, select each of the new Linux partitions in turn and click — to remove them, then return to step three. The 'Device for boot loader installation' drop-down menu should point to your drive (/dev/sda), so verify this is the case before clicking 'Install Now'. Review your chosen partition settings and click 'Continue' to apply them and install Mint.

Tweak dual-boot settings

DISCOVER HOW TO SWITCH BETWEEN LINUX AND WINDOWS USING GRUB.

When Mint installs itself, it changes the bootloader at the beginning of your hard drive to a program called GNU GRand Unified Bootloader (Grub). Put simply, Grub scans your hard drive for visible operating systems and then presents you with a boot menu, allowing you to switch between them. In most cases — specifically those where your Windows install is detected by the Mint installer — this should be set up to work perfectly from the off. You start your PC, Grub displays the boot menu, and if you don't make a choice within five seconds, it'll start to load Linux Mint.

In this event, the only thing you'll want to know is how to make changes to the boot menu — you may prefer to make Windows the default OS, for example, or you'd like to have a longer pause before Mint is selected by default. You can edit the Grub menu in the Terminal, but it's simpler to use a friendlier tool to do the job. (See the 'Edit your Grub' menu section, below.)

TROUBLESHOOTING GRUB

Unfortunately, Grub doesn't always do what you expect it to. If the Mint installer doesn't detect your Windows installation and you were forced to manually partition your hard drive, you may find your computer now boots directly to Mint with no sign of Windows. Don't worry, it's still there, but you'll need to perform some

additional steps to make it accessible. First, you'll need to boot from your Windows 10 rescue media: elect to repair your PC then select 'Troubleshoot > Advanced > Startup Repair' to restore the original Windows bootloader. This restores Windows, but leaves you with no way to access Mint — to resolve this, boot from your Mint installation media, then press Ctrl-Alt-T to open Terminal and type the following commands:

```
sudo add-apt-repository
ppa:yannubuntu/boot-repair
sudo apt-get update
sudo apt-get install -y
boot-repair && boot-repair
```

When Boot Repair launches, choose the recommended repair and follow the steps. The process involves having to copy and paste some commands into the Terminal — use Shift-Ctrl-C to copy them, then right-click in the Terminal and choose 'Paste' — as well as navigating a few additional tools. Press the Tab key to jump between options, then use the cursor keys and Space when selecting options, and finally Enter to select or proceed.

Once done, reboot your PC — hopefully both Windows 10 and Linux

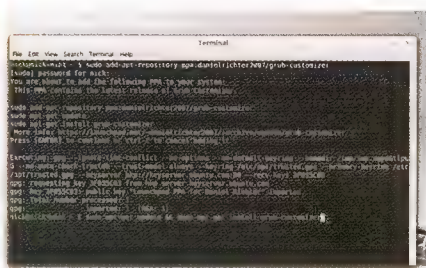
are now provided as working options in the boot menu. Note that Windows may not be referenced directly — if an entry refers to the Windows 10 bootloader, try it. This will likely work, in which case you can rename the entry using Grub Customizer.

If this doesn't happen (Grub may be present, but only offer to boot into Mint), then the repair tool may have placed boot entries directly into your PC's UEFI boot menu instead of into Grub. Start your PC in the usual way, but tap F11 or whatever key is needed to access the boot menu. You should see an additional option is present — either 'Windows Boot Manager' or 'linux' — selecting this should launch that OS, while choosing the original hard drive entry will boot the opposite OS instead. You can then choose which OS to boot into by default by entering your UEFI setup utility and examining the options under Boot (look for a 'Hard Drive Priorities' section).

If everything gets messed up completely, then simply restore your fail-safe backup using Redo Backup and start the installation process again.

"Unfortunately, Grub doesn't always do what you expect it to."

Edit your Grub menu

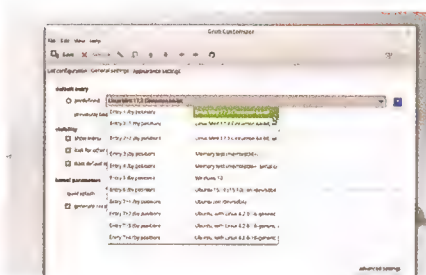


1 INSTALL GRUB CUSTOMIZER

Open a Terminal window and type:

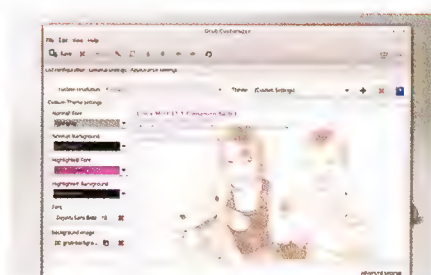
```
sudo add-apt-repository
ppa:danielrichter2007/grub-
customizer
sudo apt-get update && sudo
apt-get install grub-
customizer
```

Once done, launch Grub Customizer by clicking 'Menu' and searching for 'Grub'.



2 CHANGE DEFAULTS

Switch to the 'General settings' tab. From here, you can change the default OS via the predefined drop-down menu, or select 'previously booted entry'. You can also change the delay before the default entry is selected from this tab too — untick 'Boot default entry after' to pause Grub until an OS is selected.



3 CHANGE GRUB'S LOOK

To make a few changes to how Grub looks, switch to the Appearance settings tab where you can prettify the Grub menu by changing its colour scheme, fonts, default resolution and even apply a nice background image (Note: the image needs to be a PNG). When you've finished making your changes, click the 'Save' button to update Grub.

Your questions answered

STILL WORRIED ABOUT SWITCHING TO LINUX? LET US PUT YOUR MIND AT REST.

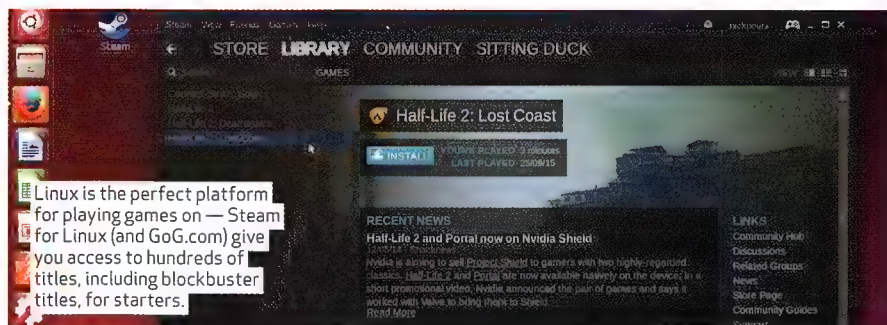
You're now ready to take your first steps into the Linux universe via the excellent Linux Mint distro, but before you get stuck in, let us explode some of the common myths and help you better understand why switching is a great move.

Q ISN'T LINUX JUST FOR GEEKS — NEWBIES AREN'T WELCOME?
Utter rubbish. These days, Linux — and Mint in particular — is firmly aimed at normal human beings. It's easy to dive in and get started, as you've already found out with the installation process, and is used for a wide variety of professional and personal purposes.

Q ISN'T LINUX ALL ABOUT THE COMMAND LINE?
Most Linux distros ship with a default desktop environment. You can even swap desktops to find the one that suits the way you work best. The underlying OS is still accessible via the command-line Terminal, which works in a similar way to the Windows Command Prompt.

Take the time to learn some of these commands and you'll find the Terminal is a fast and convenient means of getting stuff done, but Mint provides plenty of point-and-click tools, and in most cases, you can avoid the Terminal completely.

Q THERE AREN'T ANY DECENT PROGRAMS ON LINUX, RIGHT?
Many developers provide native Linux builds of popular programs — check their websites before doing anything else. You'll also find plenty of free, open-source alternatives to favourite applications you've been using in Windows. Linux is renowned



for its free, open-source roots, but don't worry, there's plenty of commercial software out there too. Finally, it's also possible to run many Windows programs directly in Linux through the Wine utility. We'll show you how later on in this feature (see p81).

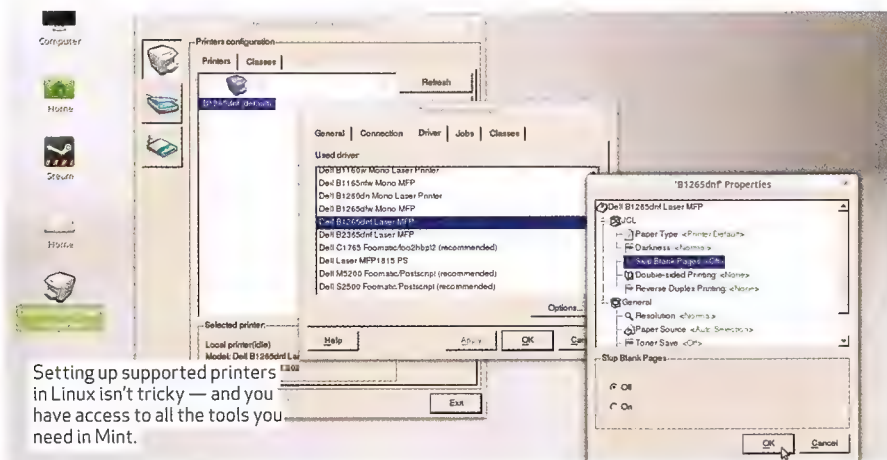
Q CAN I PLAY GAMES ON LINUX?
Sure you can. You'll find that over 1,900 games are available through the Software Manager alone. Select Games from the main screen to browse. Look out for the free DOSBox Emulator, which you can use to play your old Windows games from the last millennium. Also check out Good Old Games (www.gog.com), which offers new titles and over 1,300 DRM-free classics made compatible with Linux. The Steam gaming platform (store.steampowered.com) is also available for Linux where you'll find over 1,500 games — many blockbuster titles — available to buy and download. In fact, Linux is a better platform for games than Windows thanks to the fact it makes fewer demands on your system resources, and developers have come to recognise this, providing native support for renowned gaming engines like the CryEngine.

Q LINUX WON'T SUPPORT MY HARDWARE, RIGHT?
In the vast majority of cases, you'll find your PC's core components work fine with Mint, while most hardware manufacturers provide dedicated drivers for external peripherals and hardware, from Wi-Fi adaptors to printers and scanners. Indeed, thanks to CUPS, installing and managing printers is a relatively painless process.

One area where Linux has really improved is support for graphics cards. Mint installs generic drivers during the installation process, but you can replace these with optimised drivers from your card's hardware manufacturer. Click 'Menu > Administration > Driver Manager' to switch from the open-source driver to a proprietary one if it's supported, or visit the manufacturer's website to manually download the drivers.

Q IT'S FREE, SO I GUESS THERE'S NO SUPPORT?
Take a trip to www.linuxmint.com/links.php and you'll find documentation and a vibrant, active community offering support and answers through forums and a chat room. Take the time to search on the internet, and you'll find the vast majority of your questions have already been answered.

Q LINUX ISN'T RELIABLE OR SECURE, RIGHT?
Wrong — on both counts. Linux is no less reliable than Windows or OS X, and in many ways, it's more robust. It's also far more secure than its rivals, and not just because of the way it handles user privileges. Linux's open nature makes it better scrutinised, while the diverse number of distros make it less of a target for hackers.



Setting up supported printers in Linux isn't tricky — and you have access to all the tools you need in Mint.

Your first steps in Linux

DISCOVER ALL THE CORE SKILLS YOU NEED TO START USING LINUX MINT.

When you boot into Mint for the first time, you'll find it looks very similar to Windows. The default desktop is called Cinnamon, and is structured in a similar way to the Windows desktop: there's the equivalent of the Start menu, Taskbar and Notification area at the bottom of the screen, with desktop icons providing shortcuts to key locations.

Click the Menu button and up pops a menu with easy access to all your programs, grouped into categories. Speed things up by typing the first few letters of the program you're looking for into the Search box and it'll appear in the list of results, just one click away. On the left-hand side of the menu, you'll see some other handy shortcuts — at the top key programs like Firefox (web browser), Software Manager (for finding and installing new applications), System Settings (the Mint equivalent of the Control Panel), Terminal and files manager. At the bottom are buttons for locking, logging out and shutting down or restarting your PC.

Add your own shortcuts by dragging and dropping items into the list from the desktop or right-hand side of the menu. You can also pin shortcuts to the panel (Mint's equivalent of the taskbar) at the bottom of the screen too — just right-click and choose 'Add to panel' to do so.

Mint's panel is actually more configurable than Windows' Taskbar — you'll see lots of useful options in the bottom right-hand corner, and you can

customise these, plus add new panels, simply by right-clicking the panel and selecting from the options on show.

ACCESS DRIVES

Mint works with a wide range of file systems, which means your existing NTFS and FAT32 partitions are visible from the moment you boot into the desktop. The best place to access your drives — and browse your files generally — is with Mint's equivalent of the File Explorer. It's named Nemo, and is accessible via the Files shortcuts you'll find on both the pane and the Menu. You can also open it by double-clicking the Computer or Home icons on the desktop.

The layout is similar to Windows 10's File Explorer, with your files displayed in the right-hand pane, and a series of shortcuts to key locations on the left. You can also bookmark favourite folders (select the folder in question and choose 'Bookmarks > Add to Bookmarks') for easy access from here, too. Nemo also supports tabbed windows, which work in a similar way to your web browser, albeit with folders. Press Ctrl-T to add additional tabs, which make it easy to switch between multiple drives and folders without cluttering up your desktop with lots of open windows. You'll see an option for accessing your network in Nemo — click the Network shortcut in the left-hand pane to find other computers, and have your username and password ready if necessary.

You should find your PC's hardware has been, for the most part, automatically detected and set up. Click the Menu and choose 'System Settings' to review current settings under the Hardware section. You can source missing drivers from the manufacturer's website if necessary.

Now you've dipped your toes in the water and discovered it to be not that deep (or cold), take your first system backup of your new dual-boot system using Redo Backup. Once complete, you can start to dig a little deeper into Linux.

Let's start with the file system — Windows uses NTFS; there's the universal FAT32 file system, of course, and now you've got a third file system, Ext4, in place. When you boot back into Windows you'll find your Linux partitions are invisible — that's because Windows can't see Ext4.

That's why your shared data partition (if you created one) was formatted as NTFS.

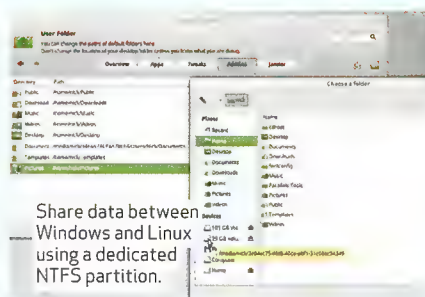


The Nemo file manager works in much the same way as File Explorer does in Windows 10, so you won't struggle to browse your hard drives.

Share data with Windows

If you plan to continue using Windows and Ubuntu alongside each other, it pays to set up a dedicated data partition, then make it easily accessible to both operating systems. Use GParted from the Mint installer to set up a NTFS partition, then boot into Windows and browse to your user folder. Right-click each key data folder — Documents, Pictures and so on — and choose 'Properties > Location', then point them to the equivalent folder on your new data partition, moving the data across when prompted.

You should also disable hibernation in both Windows and Linux — data written to the shared partition while one OS is in



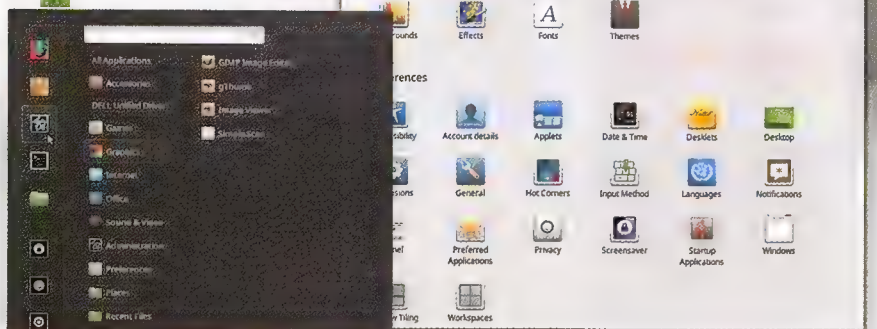
hibernation may be wiped when that OS is next woken up. In Windows, open a Command Prompt (administrator), type "powercfg /hibernate off" and press 'Enter' to enable this setting.

Once done, switch back to Mint. Disable hibernation by opening 'System

Settings > Power Management' and ensuring 'Never' is selected under the second drop-down menu. Next, open the Disks utility via the Dash. Select the disk containing your data partition in the left, then click on the partition on the right and make a note of where it's mounted (this tends to follow the format /media/<username>/<partition name>).

Finally, go to www.ubuntu-tweak.com and install the Ubuntu Tweak (yes, parts of it work in Linux Mint!). Open it from the Administration section of the Menu, then select 'Admins > User Folder' to manually point your data folders to the folders stored on the data partition you created and identified earlier.

Take more control over your Cinnamon desktop using the System Settings tools.



Open the Nemo file manager again and you'll find yourself inside the Home folder, which, if you manually configured your partitions when installing Mint, may be a separate partition. Like your Windows user folder, this contains all your personal data, but it also contains personal programs and settings too.

Click the Computer shortcut in the left-hand pane and you get to see Ubuntu in all its messy glory. Many of these folders can be ignored, while two worth noting are /media and /mnt. These are where shortcuts to all external drives and network folders are found. The key difference is that drives mounted to /media are done so on a per-user basis.

KEY SYSTEM TOOLS

The following utilities help you tweak various parts of Mint without having to use the Terminal. Click 'System Settings' to get a dialogue box similar to Windows' Control Panel. Here you'll find lots of useful tools for tweaking your installation:

The Appearance section is where you customise Cinnamon's look, but also look under Preferences for areas where you can change the Cinnamon

desktop's behaviour. If, for instance, you select 'Windows > Behaviour' tab and flick the 'Attach dialogue windows to the parent window' switch 'Off', you can change the way Mint handles each separate dialogue box that's opened if you prefer the way Windows does it.

Mint also includes a number of handy built-in tools — there's the Disks tool (which we touch on in the 'Share data with Windows' box, opposite), plus Disk Usage Analyser, which enables you to see a graphical breakdown of how your drive space is being used. The System Monitor tool is, essentially, the equivalent of Windows' Task Manager, and the Update Manager is where you go to keep Linux up to date.

THE TERMINAL

At some point, you'll need to access the Terminal. And once you've done so, you'll quickly realise it's the best way to do certain things. At the very least, familiarise yourself with the basics with this handy list of commands and you can press tab to complete commands and even file/folder names:

- **dir** — lists the contents of currently selected directory.
- **cd** — for changing directory — use **cd ..** to move up a level, **cd**

oldname to move to a subfolder within the current directory or **cd /home/<username>/Downloads** to jump to a specific directory. Note that folder names are case sensitive. To jump back to your home directory, type **cd ~** at any time.

- **cp** — copy files. Other file management commands include **mv** (move), **mkdir** (create folder) and **rm** (delete file).
- **sudo** — performs a task as an administrator. This is the equivalent of right-clicking a program in Windows and choosing 'Run as administrator'. The command precedes other commands (such as, **sudo apt-get install syncthing**) and you'll need to provide your password the first time you use it.
- **apt-get** — a tool for managing and installing packages. Use **apt-get install** to install a package, **apt-get upgrade** to update all existing software, and **apt-get check** to look for problems with software (known as broken dependencies).
- **wget** downloads files to your Downloads folder: **wget http://address.com/filename.zip**. To find out more about the Terminal, check out the beginner's guide at www.ryanstutorials.net/linuxtutorial.

QUICK TIP Drive names

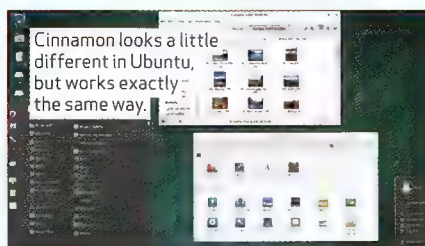
A confusing point when moving to Linux is where have all the drive names gone such as the C: drive and USB drives? Mint does a fine job of presenting removable media, but Linux doesn't use drive letters and has a more complex way of organising partitions and drive names.

Change desktops

One of Linux's strengths is that you're not tied to a single desktop. If you've installed Ubuntu rather than Mint, you'll find it comes with a very different desktop environment in the form of Unity. It's still reasonably familiar to use, but you will have to make a bigger effort to master it.

If you're struggling to acclimatise to Unity, and would rather use Mint's Cinnamon desktop instead, then you can easily do so. First, open a Terminal window and type:

```
sudo add-apt-repository
ppa:lestage/cinnamon
```



```
sudo apt-get update && sudo
apt-get install cinnamon
```

This will add the Cinnamon repository (repos) to Ubuntu, then download and install it. Once installed, you need to click the 'Settings' button in the top right-hand corner of the Unity desktop and choose

'Log out' to return to the login screen. You'll see a little Ubuntu icon appear next to your username — click this and a list of available desktops will appear, including Cinnamon. Select that to boot into your new desktop, complete with all the features we describe on the rest of this page. You can always switch back to Unity from the login screen.

If you subsequently outgrow the Cinnamon desktop, then you can easily switch desktops in Mint too.

You can even install multiple desktops and move between them as circumstances dictate.

Install apps in Mint

HOW TO FIND AND ADD NEW PROGRAMS TO YOUR DISTRO.

Now that you're up and running in Mint, you'll be wanting to start making productive use of it. That naturally involves running applications and utilities. Start by taking an inventory of the programs you use in Windows and checking the website for each to see if a Linux build is available. If there isn't one, don't panic – you'll find the vast majority of Windows applications have an equivalent version for Linux. Better still, many of these are both free and open source, so you won't need to splash out to use them, but do of course donate to them.

The most obvious place to start is your office suite. When it comes to replacing your word processor, spreadsheet, database and presentation tool, you'll find everything you need is already built into Mint via the free LibreOffice software, which can be found under 'Menu > Office'.

If you're looking for a specific open-source alternative to your original proprietary program, start your search at bit.ly/SoftwareEquivalents where you'll find links to other useful resources such as www.osalt.com. If you still can't find anything suitable, try alternativeto.net.

The simplest way to obtain and install software in Mint is through the Software Manager. It offers a neat, user-friendly front-end for finding and installing programs. Programs are organised into ‘repositories’ (or repos) and if your target program isn’t in the repos supported by the Software Manager you’ll have to find alternative ways of getting them.

First, visit the program's home page – here you may be offered a convenient downloadable installer in the form of a Deb package – choose the 32-bit or 64-bit download (if offered) to match

the version of Ubuntu you installed. Once downloaded, navigate to your Downloads folder, double-click the file and follow the prompts to install it.

Other programs may require you to install them through the Terminal. This usually involves first adding the program's repos using the following command:

```
sudo add-apt-repository  
ppa:user/ppa-name
```

The **ppa:** stands for Personal Package Archive, which is a special software repos – generally focused on Ubuntu – that anyone, usually a software team, can establish for uploading source packages for anyone to download. Replace **ppa:user/ppa-name** with the PPA provided by the software producer. Once done, you can then install packages from that repos, either through Software Manager or – seeing as you’re already

in the Terminal – with the following command:

```
sudo apt-get update && sudo
apt-get install <program>
```

Replace **<program>** with the name of your target program and it'll be downloaded and installed. Once added, you can view and manage all repos via 'System Settings > Software Sources'.

STAY UP TO DATE

Programs you install through repos – either via the Terminal or Software Manager – are checked for updates on a regular basis, namely within 10 minutes of first booting up and then every two hours thereafter. That should be frequent enough for the vast majority of people, but you can check manually, too, using one of two methods. The first is done with Cinnamon: open 'Menu > Administration > Update Manager' and

"You'll find the vast majority of Windows applications have an equivalent version for Linux."



POPULAR ALTERNATIVE APPLICATIONS

WINDOWS APP	ALTERNATIVE	WHERE TO GET IT
WORD, EXCEL, POWERPOINT, ACCESS	LIBREOFFICE	PRE-INSTALLED
PUBLISHER	SCRIBUS	SOFTWARE MANAGER (SM)
PHOTOSHOP	THE GIMP	PRE-INSTALLED
WINDOWS MOVIE MAKER	OPENSHOT	SOFTWARE MANAGER
ADOBE READER	DOCUMENT VIEWER	PRE-INSTALLED
ITUNES	AMAROK	SOFTWARE MANAGER
WINDOWS MEDIA PLAYER	VLC MEDIA PLAYER	SOFTWARE MANAGER
INTERNET EXPLORER	FIREFOX, CHROMIUM	PRE-INSTALLED OR SM
OUTLOOK/WINDOWS LIVE MAIL	THUNDERBIRD, EVOLUTION	PRE-INSTALLED OR SM
SKYPE	PIDGIN	SOFTWARE MANAGER

click 'Refresh' to manually check here, and choose 'Edit > Preferences > Auto-Refresh' tab to change the time between update checks (days, hours and minutes are supported).

To check for updates via the Terminal, type `sudo apt-get update` and hit Enter. You may find the application versions in the Software Center aren't as up to date as those provided on the program's website — by adding the relevant repos, you can ensure the latest version of the program is installed, and gain access to beta and other pre-release builds.

Install Windows apps

IF ALL ELSE FAILS, USE WINE TO RUN WINDOWS PROGRAMS IN LINUX.

The best way to run applications in your new Linux Mint install is natively, but if there's a specific Windows program you can't do without, then it may be possible to get it running. What you'll need is a special program called Wine, which uses some clever trickery to use parts of Windows, enabling you to run many Windows programs as if they were native Linux ones.

Wine can be a tricky tool to master, but thanks to the free PlayOnLinux tool, you can get many popular applications up and running with the minimum of fuss. Open the Software Manager, then search for 'PlayOnLinux'.

Click 'Install' and it'll automatically download and install Wine. Once installed, launch PlayOnLinux and allow it walk you through the first-use wizard. You'll be left with a blank window, so click the 'Install' button to get started. The Install menu allows you to search for programs or browse by category, with options including Games, Graphics and Office. Once you've found a program you want to install, select it and click the 'Install' button. You may need to supply the program's installation disc, while commercial applications will require a licence and – if applicable – activation. Just follow the wizard through:

PlayOnLinux simplifies the process of installing any supported apps because it knows which additional components need downloading and how to configure them.

PlayOnLinux's supported apps database is relatively small – aside from Microsoft Office, notable examples include Spotify, QuickTime Player and Adobe Photoshop (CS4 or CS6 only). That's because it primarily focuses on games. If you find the application you want isn't listed, don't worry – Wine supports more programs than those listed by PlayOnLinux, but the install process is a more complicated. Start by checking appdb.winehq.org to see if the application is supported. If it's present, you'll see a list of tested versions, complete with rating ranging from Platinum all the way down to Garbage. Anything rated Bronze or better is likely to work in Wine, although you may find some glitches occur. Once done, follow the step-by-step guide (see below) to attempt installation through PlayOnLinux's manual option. If you run into problems, consult the web pages for more advice, or try experimenting with different settings, but hopefully you'll end up with an application that does at least perform most key functions without problems.

APPLICATION CONFIGURATION

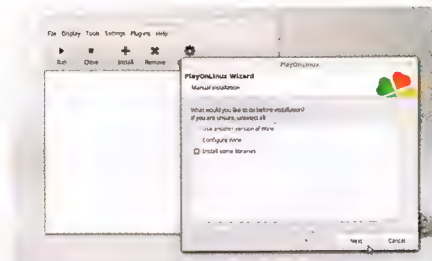
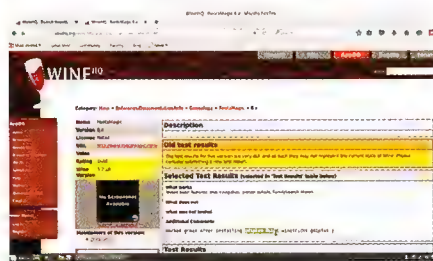
Each program exists inside its own virtual space, which you can tweak by selecting it on the main PlayOnLinux screen and clicking 'Configure'. Most advanced configuration options are found under the Wine tab – click 'Configure Wine' to access a multi-tabbed dialogue box.

Wine should automatically map your home folders to their equivalent locations in the virtual drive, but make other locations more easily accessible from the Drive tab. Click 'Add', select a drive letter and then browse to the directory. Look under the /media folder for separate drives. Once selected, it'll now be accessible within the program via the drive letter you allocated to it.

If there's no mention of it at in the Wine HQ database, don't assume it won't work: you can't harm Linux, so feel free to try, using the program's website to determine what additional components (such as the .NET Framework) you might need.

All of this should get you off to a solid and happy start to using Linux. ■

Manually install an app using PlayOnLinux



1 TAKE NOTES

Go to appdb.winehq.org, find the program you wish to install and verify the version you're installing is compatible (if it's not listed, but earlier versions are compatible — experiment!). Also make a note of any comments about additional installation requirements, such as **gdiplus.dll**. Now visit the program's website and download the program installer if you don't have an installation disc.

2 SET UP VIRTUAL DRIVE

Open PlayOnLinux, select Install and then click 'Install a non-listed program'. Click 'Next', select 'Install a program in a new virtual drive' and click 'Next' again. Name the drive after your program, click 'Next' and then tick the relevant options — in most cases just 'Install some libraries' before clicking 'Next'. Leave the 32-bits option selected for compatibility reasons and click 'Next' again.

3 ADD LIBRARIES AND INSTALL

Install any recommended packages when prompted. Once done, place a tick next to each required component (typically under **POL_install**) and click 'Next', then wait for them to download and install. Next, either select your CD drive or choose 'Select another file' to locate and run the installation program. Follow the setup wizard, then launch the program to verify it works before adding shortcuts to finish.

howto

» QUICK TIPS

Experts solve your computing problems

APC and its readers can be one giant helpdesk. If you have a technical problem, chances are one of us can solve it.

WINDOWS

REMOVE MICROSOFT ACCOUNT FROM PC

I have a simple problem — how do I remove my account from one PC which I am giving away, without removing my Microsoft Account all together? I have other PCs that use my account.

Ian Brighton

Removing a Microsoft Account from your PC has no effect on your Microsoft Account in general, other than to remove the association between it and your PC. In theory, it should work in the same way as removing a regular user account.

First, we asked Ian who he was passing the PC on to — if you're selling it or giving it to charity, it's a good idea to revert it to factory settings first using your PC's recovery partition or disc, and if there's sensitive data on the drive, use a free program like CCleaner (www.piriform.com) to securely wipe the free space so all traces of documents and other data are removed.

Ian was passing the PC on to his grandson, so this isn't necessary. What you need to do in this instance is first click 'Start > Settings > Accounts'. Choose 'Family & other users'. While it's tempting to use the option to add a family member, if you're no longer using the PC the best thing to do is click



'Add someone else to this PC'. You can then link this to an existing Microsoft account or click 'I don't have this person's sign-in information' followed by 'Add a user without a Microsoft account' to create a local user account. Once created, click the user's new entry and choose 'Change account type' to switch them to administrator. Click 'OK'. When you're ready to remove your own account, log off and then log on as the new user. Return to the 'Settings > Accounts' screen where you'll be able to select your own account and remove it (with its files) from your PC, ready to hand over.

Graham Barlow

HARDWARE

SET THE RECORD STRAIGHT

I plan to build myself a new PC, but before I do, please could you clarify M.2 support, as found in my Asus X99-E WS/USB 3.1 user manual? "This motherboard features the M.2 slot, which shares bandwidth with PCI

Express 3.0 x4 slot to speed up data transfer up to 32Gbps. This helps enhance the performance of your SSD... that is dedicated only to the operating system." My questions are:

** Is M.2 only useful when the operating system is installed on to one dedicated SSD?*

** Is there any benefit to utilizing M.2 when the OS is installed on a RAID 10 array (across four 256GB Samsung 950 Pro SSDs)?*

** I read online that enthusiasts install their OS (with a lot of hassle) directly on to the M.2-based drive. Does this offer the best performance compared to my alternative method?*

Thank you very much for any help you can give.

Jerry Franco, Jr.

The maximum throughput of a modern SATA port is 6Gbps, whereas a four-lane M.2 slot is theoretically capable of up to 32Gbps. The fastest SATA-attached

To use a smaller SFX power supply with a full-sized ATX chassis, you need an adapter — which often must be purchased separately.



If your graphics card isn't being supported by AMD or Nvidia's most-recent drivers, it's probably time to upgrade.

Create an account for this PC

If you want to use a password, choose something that will be easy for you to remember but hard for others to guess.

Who's going to use this PC?

User name

Make it secure.

Enter password

Re-enter password

Password hint

To transfer a PC to a new friend or family member, create a new account and give it administrator rights, then delete your old account.

Back

Next

drives can push sequential transfers just over 500MB/s. Meanwhile, Samsung rates its 256GB and 512GB NVMe SSDs (like the M.2 950 Pros) in excess of 2GB/s.

To answer your first question: no, M.2 attached to the PCIe bus isn't only useful when it's hosting the operating system. However, many of your OS's operations are small and random in nature. That's exactly where a drive such as Samsung's 950 Pro excels. The NVMe interface is optimised for low latency, which translates to increased system responsiveness. The best M.2 drives are faster than a striped set of mirrored SATA SSDs. What you lose, of course, is the redundancy of those mirrors. If this were our new PC, we'd drop a 256GB drive into the M.2 slot for Windows and our most performance-sensitive apps. Then we'd re-use those other three 950 Pros, perhaps leaving them in RAID 10 to store user data requiring some degree of protection. There's even room for a third tier of mechanical disks, should you need additional capacity.

APC team

HARDWARE

BATTLING BAD BEHAVIOUR

I recently updated my Windows 8.1 system to Windows 10. It ran for a couple of weeks, but then started to exhibit display corruption, slow browser refreshes, desktop color craziness (all text and backgrounds turn clear so you cannot read any of the menus), and eventually I have to reboot.

It's good for another few minutes after that. Most of my issues manifest while I'm browsing the web, but can crop up at any time. The system board is an Asus P7P55D-E with a Core i7-860, and 12GB of RAM; I have a Radeon HD 5700-series video card plugged in, too. AMD does not have any drivers newer than the ones I'm running (15.201.1151.0).

Do you think that, due to the relative age of the video card (it's around three years old now), it's time to buy a newer one that might coexist better with Windows 10? I didn't have any issues with Windows 7 or Windows 8.1. If you recommend a new board, what would be a reasonable choice? I don't do much gaming, but do appreciate a peppy system. I have tried uninstalling the current video drivers, rebooting and letting Windows discover the card on its own. That works for a little while, after which I'm battling the same issues.

David Knapp

The troubleshooting process is fraught with frustration and hard-fought victories. In this case, the fact that you can recover stability and then quickly lose it once again suggests you could have a component that might be cooling down and then overheating. Have you popped the side off your chassis to check that all is well with the Radeon's cooling fan? How about using GPU-Z to monitor the temperature of AMD's Juniper processor? If everything checks out on the hardware side, try starting over with a fresh driver install. Use DDU (www.wagnardmobile.com/DDU) to clean

out any remnants of older Catalyst versions, and then grab the 15.11.1 Beta (amd.com/beta), which is a little newer than what you were using before.

At the end of the day, though, that graphics card is getting old, and AMD hasn't supported it with any recent driver updates (the latest Radeon Software Crimson Edition build only goes as far back as Radeon HD 7700+ support) – so you might want to start thinking about an upgrade.

APC team

HARDWARE

PSU COMPATIBILITY

A while back, I bought a PSU for my sister's desktop. The stock unit died and I didn't pay enough attention when I picked out the replacement; it turned out to be an SFX form factor-based supply, rather than ATX. Do I simply need an adapter bracket, or is this specific PSU useless in her machine?

Blake

Many SFX-based power supplies include adapter brackets for applications just like this one. If yours didn't, then yes, that should be all you need to get the PSU installed. Check with the manufacturer to see if it offers a bracket. They're fairly widely available on eBay as well.

APC team

NETWORKING

EATING UP BANDWIDTH

I am currently working overseas in an area that shares its Internet connection with a large number of people. They restrict access in order to prevent the connection from becoming severely bogged down. We're allowed unlimited web browsing and email, and time-limited video chat. Being away from my family is bad enough, but no online gaming is just cruel. I like to play Battlefield 4, Star Wars Battlefront and WoW. From what I hear, though, online gaming consumes minimal bandwidth compared to other online activities. Is there a good reference for making such a comparison?

Brian Eyestone

We don't have any benchmark data of our own to share, but we do know that games utilise your internet connection in different ways, and every title will chew up a different quantity of data per hour. If you were to believe Cable One's web usage calculator (www.cableone.net/Docs/datacalculator.html), though, streaming music is more than twice as intensive as heavy gaming, and video streaming uses more than 50 times as much bandwidth. Most folks probably overestimate the bandwidth requirements of online gaming.

Almost certainly, downloading the games themselves and keeping them up to date through patches would tax the connection more than a few hours of play time.

APC team ■

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FULL LIST: BEST
FREE APPS TOOLKIT

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LibreOffice
Audacity
Sumatra PDF
MusicBee
VLC
Paint.NET
Krita Desktop

SECURITY

VeraCrypt
Keepass
Avira Free Antivirus
MalwareBytes Free

NETWORKING

TinyWall
GlassWire
TeamViewer

CLEANUP & MAINTENANCE

Unchecky
PC Decrapifier
CCleaner
Speccy
WinDirStat
Process Explorer
Revo Uninstaller
IObit Uninstaller
Recuva

GENERAL TOOLS

PortableApps
7-Zip
ImgBurn
Total Commander
Everything
Passcape ISO Burner
KatMouse
WizMouse
Rufus
Autoruns
Sysinternals Suite
Greenshot
ShareX
F.lux

38 FREE
ESSENTIAL
PC TOOLS
ON DISC!



APC's best free Windows apps

Your PC is a powerful tool, but without software, it's virtually useless (virtually, because it'd make an impressively ornate door stop).

While the likes of Microsoft have long specialised in big-budget, high price applications, there are plenty of small things that these ubiquitous software suites don't allow. Want an auto-booting USB stick? Want a fully-featured audio editing suite? Want an easier way to assess your system specifications? Well, you don't need to pay for these luxuries.

On this month's disc, you'll find over 35 free software products ranging from security (BitDefender), entertainment (VLC), home office (LibreOffice) and, um... mouse tracker amplification (WizMouse). While it's unlikely every user will use every piece of software herein, it's sure to be a useful resource for when you want something done that your existing software collection is incapable of. These are all pieces of software that members of APC's own team have used and can personally recommend.

Now, we've got one last quick bit of advice before you start installing these programs en-masse – start by setting up Unchecky from the cleanup and maintenance section. It's a great little tool that's able to mostly prevent the installation of any 'potentially unwanted programs' – aka PUPs – that free apps often come bundled with. If you're constantly trying out free software, it's the best way of avoiding things like browser toolbars or just junk apps that you didn't ask for.

SYSTEM REQUIREMENTS

- A DVD-ROM reader or burner.
- The APC disc is designed for use with up-to-date browsers (for example, Edge, Chrome, Firefox).
- The interface included on the APC disc requires a JavaScript-enabled browser.
- An internet connection may be required for online registration of software before use.
- The software packages on the APC disc have different system requirements. Software is included on the disc for Windows 7, 8 and 10.

BEFORE INSTALLING

- Check the disc using a virus scanner complete with the latest antivirus data updates. The disc was checked before burning, but new viruses are being discovered all the time.
- Back up any important system and data files. It is not recommended that the software contained on these discs be installed on production machines.
- If you have any questions regarding the use of the APC disc, click the 'Help' button at the top of the screen.

USING THE DISC

- Insert the disc into a CD/DVD-ROM reader or burner and your web browser should automatically load the interface. If not, launch your web browser and load the default.html file from the root directory of the disc.

HELP

- If you have any problems with the APC disc, please visit www.apcmag.com/disc
- APC provides no technical support for this disc or any software provided on it.

NO DISC?

Please note the free disc is not included with digital editions or bundled promotional copies of APC.

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apc

Get to grips with Anniversary Edition's tablet upgrades

Nick Peers shows how to take full advantage of tablet-friendly changes in the Anniversary Edition.

The Windows 10 Anniversary Edition update contains a number of new features and useful improvements, particularly if you're running Windows 10 on a tablet or laptop with a touchscreen. Probably the most noticeable is the introduction of Windows Ink, a feature designed to encourage use of touchscreens and supported styluses. Although it's designed to work with the Surface Pen, many features will work with capacitive styluses and even your finger too, making it useful for any touch-friendly device.

In this tutorial, we'll examine how Windows Ink works, and also take a look at other improvements aimed at tablets and laptops, such as tweaking battery life settings and exploring changes to Tablet Mode. There's even a feature to wirelessly share your tablet screen with your PC.

Jargon buster!

Capacitive stylus

A cheap stylus that works in the same way a finger does when touching a touchscreen. No pen-specific features are supported.

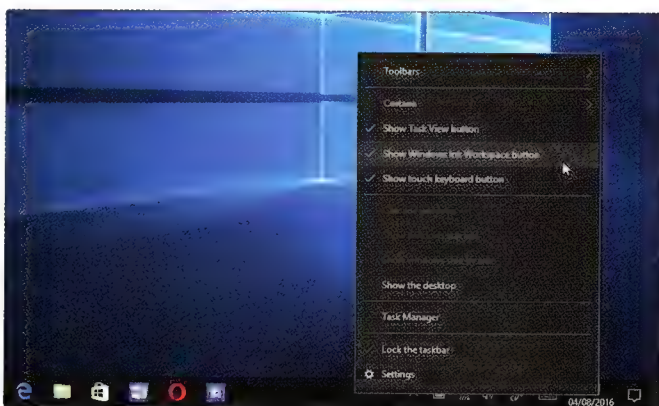
Bluetooth stylus

A stylus that communicates with your PC over Bluetooth to provide pressure-sensitive readings, offering greater accuracy and more features.

Metro interface

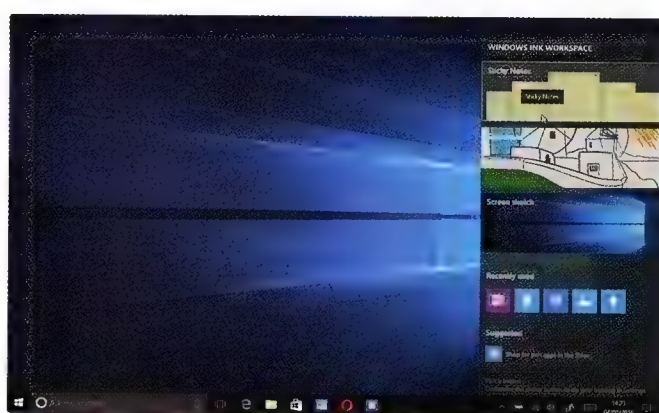
The tile-based user interface introduced in Windows 8 that was originally meant to replace the traditional Windows desktop.

Take advantage of the Anniversary Edition updates



1 TAP INTO INK

The Windows Ink Workspace is accessible through the new pen button that appears in the Taskbar Notification Area. It should be enabled by default on any touchscreen device, but if it's not visible, simply right-click the Taskbar and tick 'Show Windows Ink Workspace button', then click it. The workspace will pop up on the right of the screen. You'll see it's split into various sections.



2 NEW APPS

At the top of the window, you'll see shortcuts to three new apps: Sticky Notes, Sketchpad and Screen sketch. Sticky Notes still requires a Bluetooth-powered stylus — Wacom is developing a universal stylus for all Windows tablets as we type. If you have such a stylus, you can write or draw, and if your writing is neat enough, Cortana will read your notes and suggest reminders.



1 CHOOSE YOUR PEN

You have a choice of three nibs — pen, pencil or felt tip. Tap one to choose a colour and set the brush size.

2 RUB OUT MISTAKES

Select the eraser, then tap on an unwanted part of the sketch — it'll be wiped automatically.

3 MORE CONTROLS

These buttons let you disable or enable touch and pen input, undo or redo the latest changes and crop the image.

4 START FROM SCRATCH

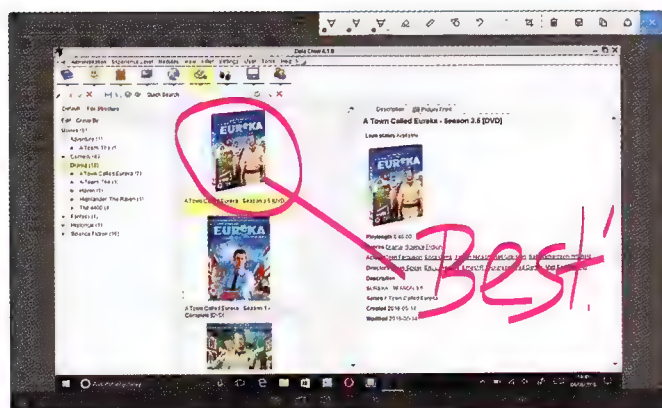
Tap the bin icon to wipe the screen and start from scratch — if you tap it by mistake, tap 'Undo'.

5 EXPORT IMAGE

Click the disk icon to save your image as a PNG file. Other options are to copy to the clipboard or share to another app.

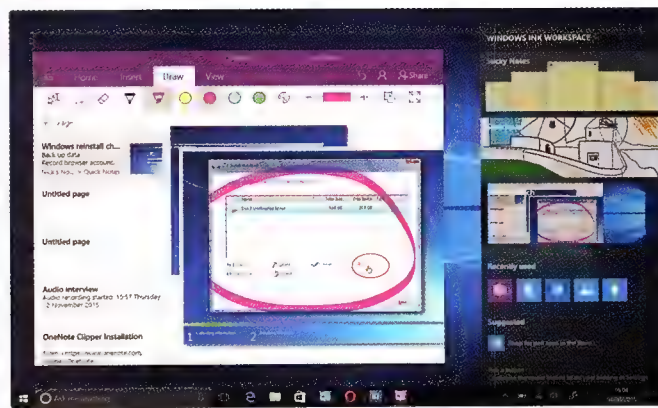
6 USE THE RULER

Tap the ruler button to place the ruler on the page, then drag and rotate into position to draw clean, straight lines.



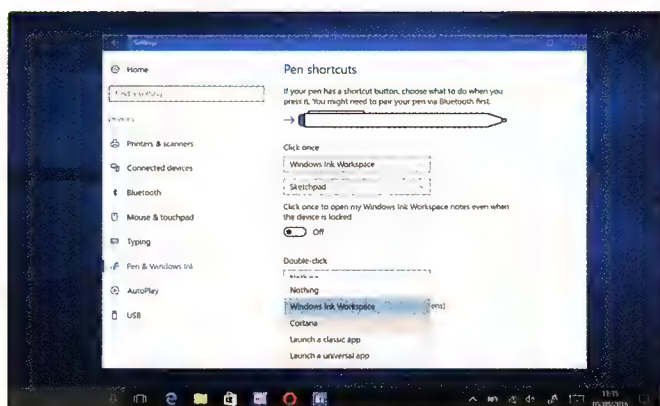
3 SCREEN SKETCH AND SKETCHPAD

Tap 'Screen sketch' to take a screenshot of the current screen and then annotate it using your pen or finger to draw shapes or scribble handwriting. Look for the finger button at the top of the screen — tap this to switch off handwriting if you'd rather use the mouse to draw instead. Sketchpad works in a similar way — see the annotated screengrab for details.



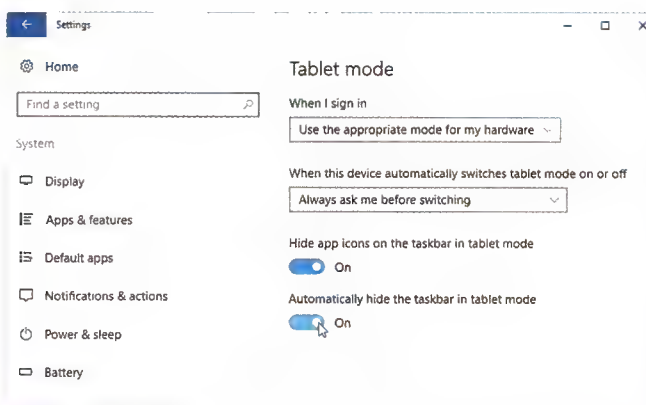
4 MORE WORKSPACE TOOLS

A list of recently used apps that support Windows Ink appears underneath the main list — tap one to open it and then locate the relevant tools you need. OneNote users should switch to the 'Draw' tab and select a nib to begin drawing. You'll also see a link to the Windows Store, which will take you to a list of other available apps that support Windows Ink.



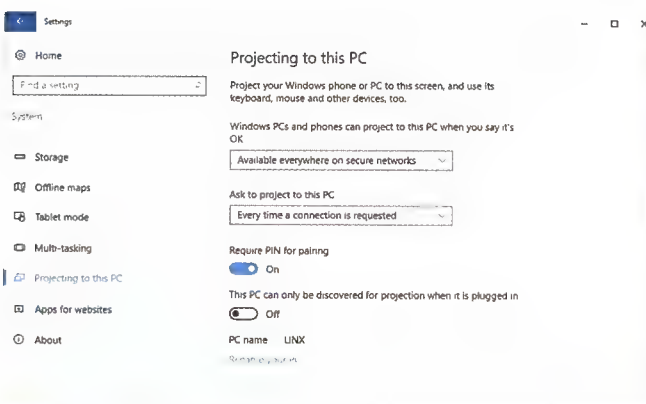
5 WINDOWS PEN SETTINGS

You'll also see an option marked 'Pick a button' at the bottom of the workspace — if you have a supported Bluetooth stylus, tap this to jump to 'Settings', where you can now assign specific apps or commands to the button when you click or double-click it. Other tweaks include choosing which hand you write with and disabling touch input when the pen is in use.



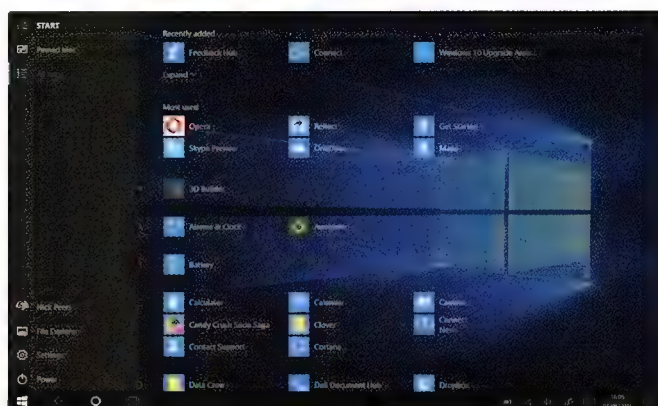
7 HIDE TASKBAR FROM VIEW

Click 'Start > Settings > System > Tablet mode' and you'll find the options have also updated. As before, there's an option to show app shortcuts on the Taskbar if you wish, but now you can also hide the Taskbar completely from view when running apps (it'll remain visible when you're at the Start screen — just press the Windows key to open it at any time).



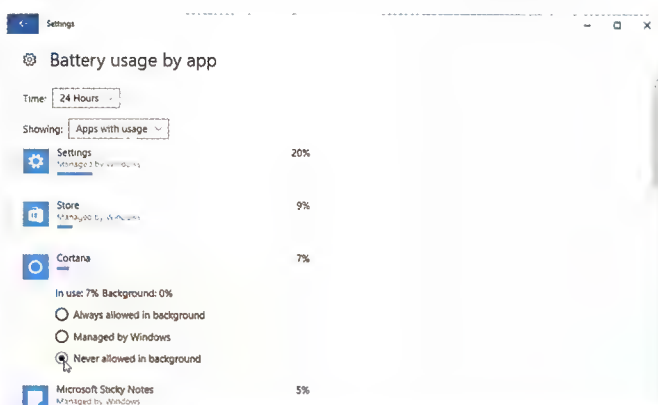
9 PROJECT YOUR PC

It's now easier to wirelessly project the screen from one supported device onto another, allowing you to use your PC or tablet's displays as extensions of each other. Both devices must support Miracast (your PC might not). Go to 'Systems > System > Projecting to this PC' on each device to verify compatibility, then select 'Available everywhere on secure networks'.



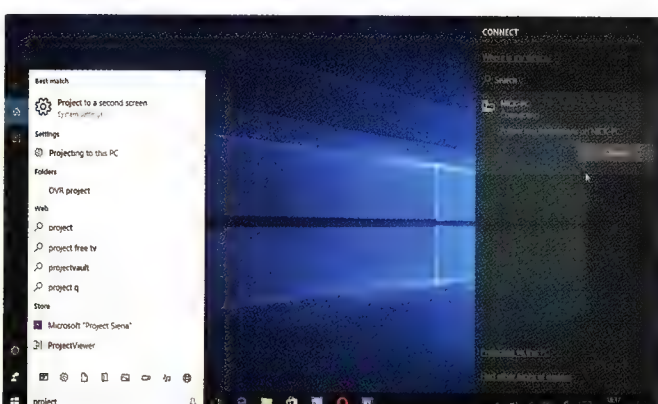
6 TABLET MODE CHANGES

Switch to Tablet Mode and the screen looks more like the older Metro interface from Windows 8, with Pinned Tiles on top and the 'All Apps' list beneath it. Switch views using the buttons in the top left-hand corner of the screen. Look out for handy shortcuts above and to the right of the Start button, including a back button to retrace your navigation to the previous step.



8 IMPROVE BATTERY LIFE

Go to 'Start > Settings > System > Battery > Battery usage by app'. You'll see that Windows is set to manage all apps automatically, but if you suspect certain programs are taking power from your battery (even when not being used), tap them on this list, verify their background usage and change the setting to 'Never allowed in background' to stop them in their tracks.



10 MAKE CONNECTION

Once set up, type 'projecting' into the Search box of the device you want to extend and click 'Project to a second screen'. Select 'Connect to a wireless display', select your target PC and wait for the connection to be made. Once done, you'll be able to use its screen as an extension of your tablet — either to duplicate its contents or to extend your tablet's desktop wirelessly.

Naming shapes and running macros in PowerPoint

Helen Bradley explains how to name shapes in PowerPoint and how to use them to trigger actions in her last-ever macros column.

PowerPoint VBA lacks some features which are readily available in other applications. It doesn't include a macro recorder, so it can be tricky to find the information you need to code macro solutions. This month and in my final macro column for APC, we'll focus on finding the name of a PowerPoint shape, renaming a shape and programming shapes to do something at presentation time.

NAMES AND SHAPES

To find the name of a shape in PowerPoint, you can do one of two things; you can locate it via the Selection pane or you can write some code to do the work for you. This code will return the name of a shape that you click:

```
Sub shapename(selectedShape As Shape)
MsgBox "The name of the shape you clicked is: " + vbCrLf + selectedShape.Name
End Sub
```

Add this code to a module in a PowerPoint presentation. To run it, you will need to attach it to a shape or a picture. You do this by selecting the shape and, from the Insert tab, choose 'Action > Mouse Click' tab,

click the 'Run Macro' option and click to select the macro name. Now, when you run your slideshow, you can click the shape or picture to view its name.

RENAME A SHAPE

You can use code to rename a shape to give it a more meaningful name. This code, when attached to a picture or shape using the 'Action' options will, when you click the shape, show you the current shape's name and allow you to alter it to suit:

```
Sub renameshape(selectedShape As Shape)
    crlf = Chr(13)
    shapename = selectedShape.Name
    shapename = InputBox("Type a new name or click Cancel", "Rename Shape", shapename)
    If shapename <> "" Then
        selectedShape.Name = shapename
    End If
End Sub
```

INTERACTIVITY USING SHAPES

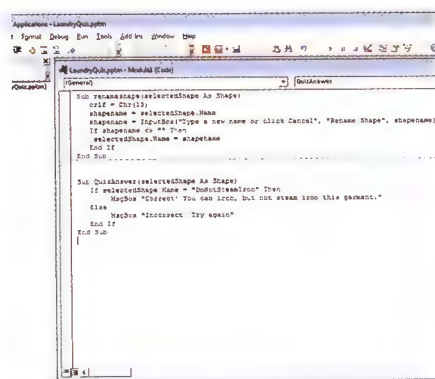
One advantage of the Action feature in PowerPoint is that you can attach

the same macro to multiple shapes and process them all using the same code. We'll use this feature to include a mini quiz on a PowerPoint slide. Using your slide, you can pose a question and offer one or more answers in the form of shapes with text added to them. Depending on the shape/answer that the user clicks, you can reply with a different response.

The step by step below shows how to configure a simple Question/Answer slide and this is the code behind the solution — the one piece of code should be attached to all the shapes:

```
Sub QuizAnswer(selectedShape As Shape)
    If selectedShape.Name = "DoNotSteamIron" Then
        MsgBox "Correct! You can iron, but not steam iron this garment."
    Else
        MsgBox "Incorrect! Try again!"
    End If
End Sub
```

Download the macros for this story at www.apcmag.com/magstuff.



1 STEP 1 Add the code to a module in the presentation. We added code to rename the shapes and the code to run the quiz.

2 STEP 2 Set up your slide — we used a picture and three shapes with text added to the shapes. We renamed the shapes, then added the code to run the quiz.

3 STEP 3 Finally, run the presentation and test the project. ■

Harness iOS 10's improved notifications

Learn how to stay informed of events and remain on top of things with Alan Stonebridge.

There are several ways to keep up to date with what's been happening while you were working in apps or when you haven't been looking at your device at all. The basics of notifications haven't changed a great deal in iOS 10. They still appear for a moment in a strip across the top of the screen when your device is unlocked, accumulate in Notification Centre and shown on the Lock screen (so you can attend to any you might have ignored or missed from one place later on) and display numbered counts on apps' Home screen icons to remind you of how many missed events you've got to catch up on.

When dealing with notifications in iOS 10, you'll find yourself jumping from banners, the Lock screen and

Notification Centre into apps to deal with things far less. That's because the updated operating system enables apps to provide more than just a bit of text and a few actions you might take in response. So, for example, when you receive a text message, as well as responding to it in place, like in iOS 9, you can scroll back through your conversation to check what was previously said.

These capabilities apply to third-party apps from the App Store too, not just Apple's own, and they provide you with much greater control without the need to yank you out of whatever app you're in the middle of using.

Notifications work largely the same across all iOS devices. If your iPhone is a 6s/6s Plus or 7/7

Plus, though, 3D Touch provides you with a more consistent experience for dealing with things quickly from one place.

LOOKING AHEAD INSTEAD

Notice that there are no longer tabs at the top of Notification Centre for moving between the Today view and Notifications. The Today view is still present, though: you only have to swipe right on Notification Centre to find it. So, on a Plus-size iPhone, you can reach and interact with the Today view much more easily while using your device one-handed. The Today view is also available at the Lock screen, where you don't even have to open Notification Centre to see it.

Finally, after you've configured an app in 'Settings > Notifications', tap its name in the bottom group at the top level of Settings; often the same controls are repeated here, but occasionally you'll find extras. Also check any configuration page within the app itself, as is the case with Facebook.

"In iOS 10, you'll jump out of the app you're using to attend to notifications far less often."

How to

Work with notifications

Settings

Notifications

Swipe down from the top of the screen to view Notification Centre.

NOTIFICATION STYLE



App Store
Badges, Banners



Calendar
Badges, Sounds, Alerts

1 SET UP AN APP'S NOTIFICATIONS

To configure notifications for any app that uses them, go to 'Settings > Notifications' and tap the app's name. Each app has the same basic set of options. Some provide extras, such as previewing messages on the Lock screen.

Notifications

Messages

Allow Notifications



Show in Notification Centre



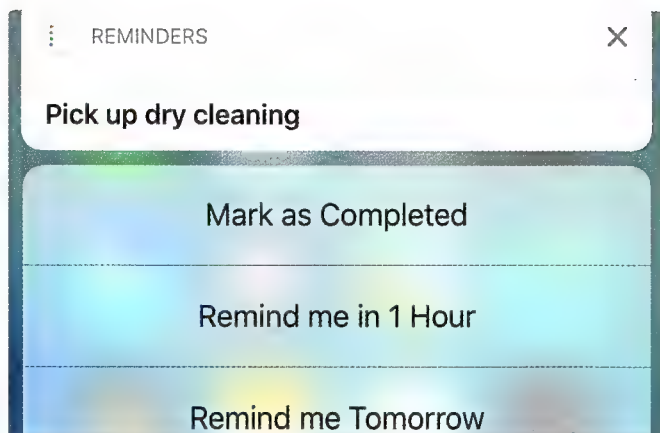
Sounds

Note

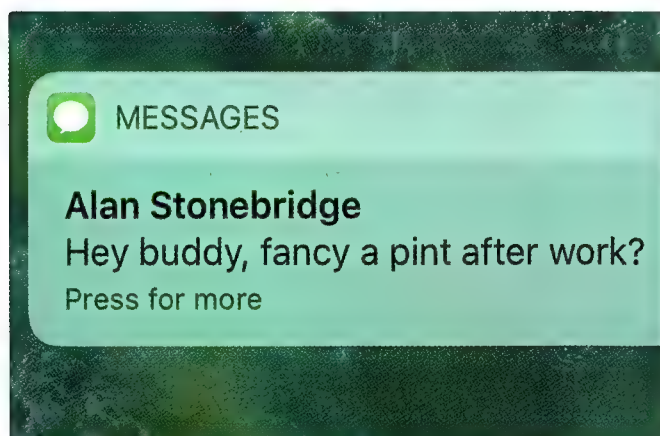


2 A MEMORY AT A GLANCE

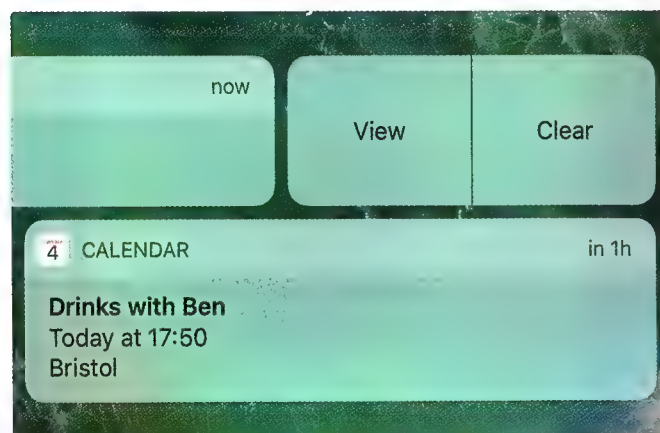
Double-click a memory to open it, then scroll down to see the pictures that Photos has decided belong together, people it has identified in them, a map showing where the photos were taken, and related memories.



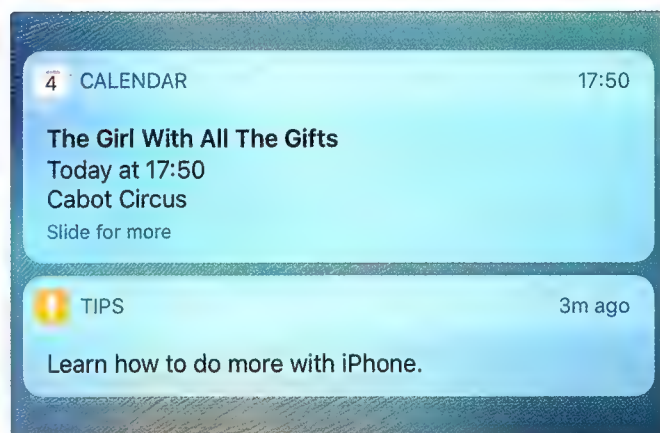
3 RESPOND TO A BANNER
When a banner (or alert) appears at the top of the screen, tap it to go to the relevant place in the corresponding app, or swipe down from it (or apply 3D Touch to the banner if your device has it) to respond from where you are.



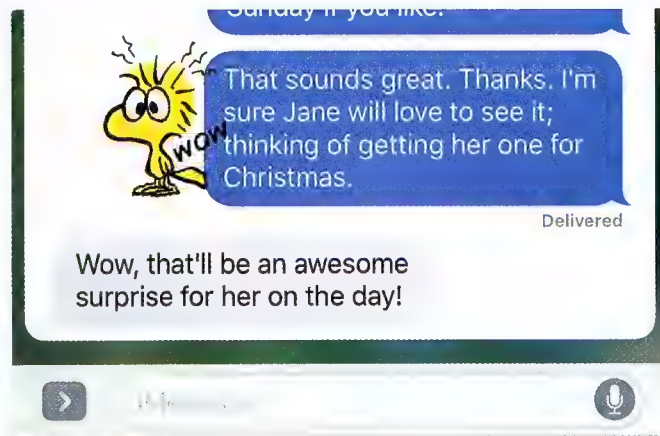
5 IT'S SIMPLER WITH 3D TOUCH
On a device with 3D Touch, you only really need one gesture: press firmly on an item in Notification Centre or on the Lock screen, to attend to it in place, then carry on with your previous task.



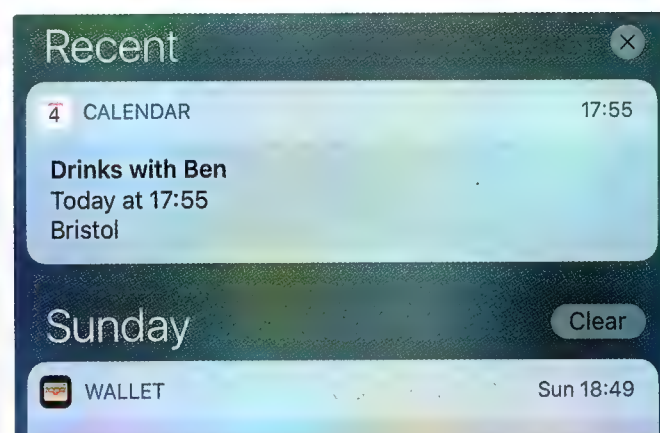
7 CLEAR OUT OLD NOTIFICATIONS
Regardless of whether your device has 3D Touch, at the Lock screen or in Notification Centre you can dismiss an item by swiping left on it and tapping Clear. Depending on the app, other commands may be available here, too.



4 RESPOND TO MISSED ITEMS
At the Lock screen, swipe right on an item to jump to the corresponding place in its app to deal with it. To respond to one in Notification Centre, tap it instead, as swiping right there will take you to the Today view.



6 RICHER NOTIFICATIONS
Regardless of whether your device has 3D Touch, iOS 10 enables apps to show richer content when you open a notification in place — a video doorbell can show a live camera feed, while Messages lets you review the chat so far.



8 CLEAR ALL NOTIFICATIONS
Notification Centre groups old items by reverse order of date. To clear a whole group of items, tap the X to the right of its heading. To get rid of all notifications, apply 3D Touch to an X and then tap 'Clear All Notifications'.

Organise photos in macOS Sierra

Alan Stonebridge shows how Sierra's impressive upgrades make it easier to find your photos.

Whether you're a hobbyist or a pro, photography is such a popular activity that it's no wonder that some of Sierra's biggest changes are in the Photos app. These improvements go further than previous changes, which addressed shortcomings that stemmed from Apple replacing the app's popular predecessor, iPhoto, and starting from scratch with its photo management tool.

One of the most prominent new features is Memories, which lives in an eponymous tab in the app's toolbar. Over time, the app picks out collections of pictures it thinks you might want to see again, typically comprised of pictures taken on or around the same date, or around a particular location.

You can scroll through this automatically generated timeline to look back at all the memories the app has picked out. However, that'll only get more unwieldy as the timeline gets longer, so the app enables you to add a memory to a collection of your

favourites, which are stored in a folder in the Albums tab. The app also lets you delete a memory if you disagree that it's something you'll want to look at often – perhaps there are one or two interesting images in it, but many more that you're not that fond of. Note that this only deletes the memory; its contents remain in your photo library.

A memory can be played as a slideshow by opening it and then clicking the toolbar's Play button, but there's no option there to export it as a movie to share with others. However, click the adjacent '+' button, choose 'Slideshow', make a few decisions, and the slideshow is saved to the Projects tab. Select it there, then choose 'File > Export > Export Slideshow'.

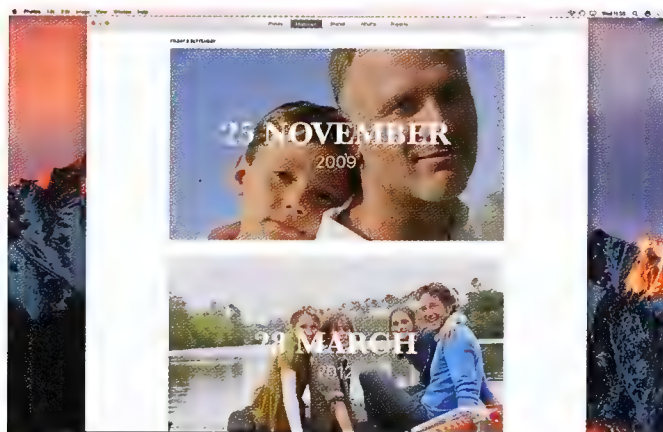
INTELLIGENT ANALYSIS

Photos' other big new feature is automatic analysis of your photos – not just so you can then browse them by the people they contain, like in previous versions, but so you can search for pictures that contain a specific object or kind of scene. Until your entire library has been scanned, the People album will show a count of how many photos have been scanned and how many remain. Analysis takes place when your Mac is connected to mains power and Photos isn't open. Open Activity Monitor, click the CPU tab and find 'photoanalysisd'; it's responsible for analysis – notice it's suspended while Photos is open and resumes its duties as soon as you quit the app.

"One of the most prominent new features is Memories, which live in an eponymous tab in the app's toolbar."

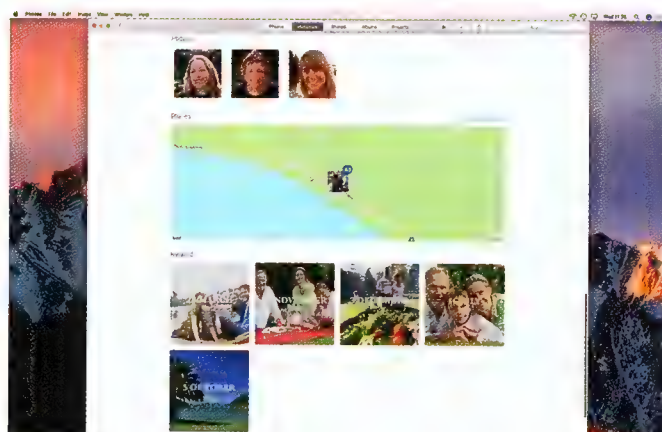
How to

Revisit photos in Sierra



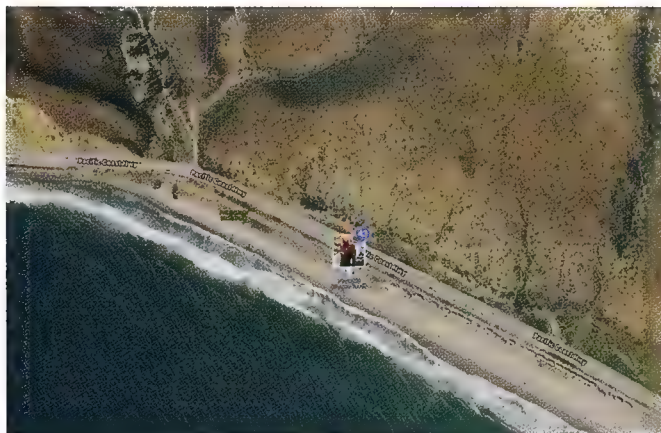
1 REVISIT OLD MEMORIES

Photos adds to the Memories tab over time, so keep returning to that tab to see what it has picked out for you. As time goes by, you'll see it fill up with large thumbnails, each with their relevant date emblazoned across their middle.



2 A MEMORY AT A GLANCE

Double-click a memory to open it, then scroll down to see the pictures that Photos has decided belong together, people it has identified in them, a map showing where the photos were taken, and related memories.



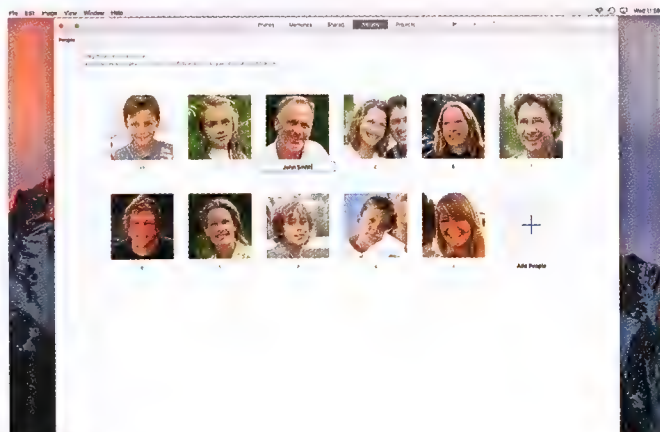
3 SEE THEM ON A MAP

If photos in a memory have location data attached, they'll be plotted on a map. Double-click the map for a closer look, or click 'Show Nearby Photos' to have the app reveal more from close by but perhaps not in this memory.



4 SAVE MEMORABLE MOMENTS

To add a memory to your favourites in the Albums tab, control-click it in the timeline and choose 'Add to Favourite Memories' — or click that at the bottom of its overview. Both places also offer an option to delete the memory.

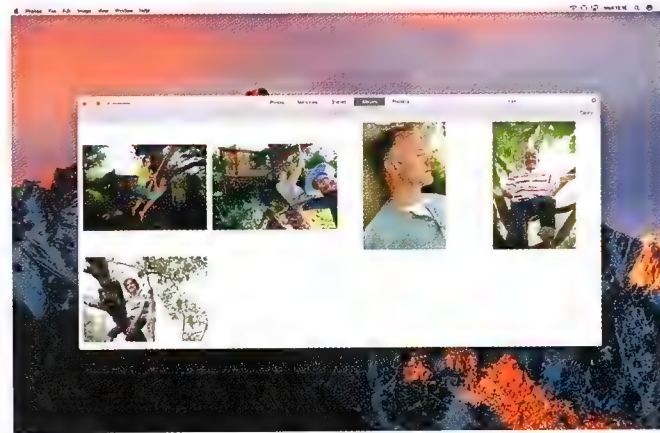
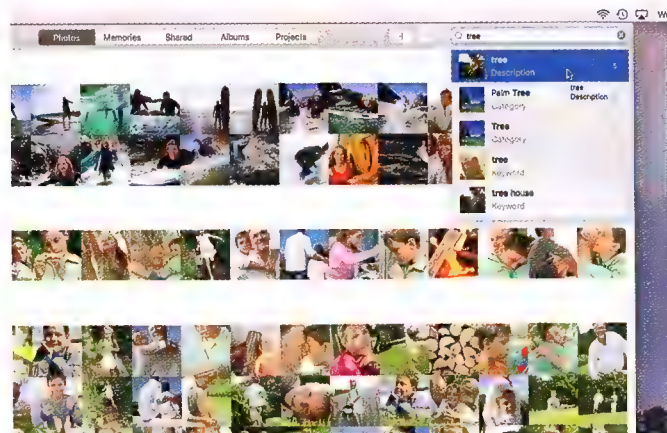


5 PLAY AS A SLIDESHOW

Memories aren't just about gathering pics in album-like groups. At one's overview, click the toolbar's Play button, choose a theme — this includes a score, which you can swap for a track from iTunes — and click 'Play Slideshow'.

6 BROWSE BY PERSON

Under Albums, open the People album to see faces the app has detected. Put the pointer over one, click 'Add Name' and type. Click 'Add People' to see more; if several are the same person, hold command, click them, then 'Merge & Add'.



7 SEARCH BY OBJECT OR SCENE

Sierra's version of Photos also recognises thousand of types of object and scene. In the search bar, enter text such as 'beach', 'tree' or 'no people'. The search engine is basic in other ways; you can't enter two discrete terms.

8 INSPECT SEARCH RESULTS

Among the list of search results will be matching items, including slight variations on the term you entered (such as 'palm tree'), and counts of matches in each category. Click a search result to see all matching photos.



DIY home theatre PC on a budget

This month, Zak Storey is on the hunt for a device that reaches the heavenly heights of headless home theater.

It's good to step away from the rig once in a while — to spend time with the family, sit down and enjoy a bit of televisual entertainment. After all, there's more to the world than pixels and digitised avatars waiting to be quashed. There's a whole variety of delights to watch, with real people, in the comfort of your own couch.

So what's the plot of this particular tale? We want to build a small form factor, headless, home theater PC, redesigned for the digital age (sans

5.25-inch drive bay), capable of streaming content over a wireless or wired network, anywhere in the home.

Because, when all's said and done, in the age of Netflix, Stan, Foxtel Go and all manner of other digital streaming services, there's really no excuse not to be streaming content direct to your big-screen TV. It's easy, it's convenient and it doesn't tie you into any unnecessary cable packages or cumbersome Blu-ray drives.

But let's face it, you can already enjoy that, thanks to the likes of Nvidia's Shield console or the increasingly popular Android TV boxes. It's the versatility of the Windows PC platform that we're after here, though.

After all, we stream, we game, we work, and we network on the platform. We should be able to watch movies and TV in comfort, too, right?

THE SPECS

This build was all about the chassis: the Fractal Design Node 304. It's an ITX beauty, capable of housing a serious amount of heft. To minimise our budget, though, we went with an Intel Pentium G3258 Anniversary Edition dual-core processor, clocking in at 3.2GHz, with 16GB of low-profile DDR3 at 1,600MT/s, a 650W PSU (a little overkill), a 120GB SSD for the boot drive, and 2TB of old-school storage for all our media. It's worth noting that the motherboard we actually put into action is the Gigabyte Z97N Gaming 5, which is unfortunately now only available for \$300 or more, used. But as the motherboard isn't going to add much in the way of performance, opting for any alternative (and cheaper) H97 mini-ITX board instead is fine.

We stuck with the retail cooler — unless you're planning on overclocking the Pentium G3258, you can get away with retail, and due to the lack of internal componentry involved, the two 92mm intake fans at the front of the chassis, and the rear 120mm, is plenty.

So a scraping together of spare parts? Sort of. That's the beauty of having older hardware lying around. However, if you were looking to do something similar with the Z170 chipset, we suggest opting for a low-end Intel Pentium

PARTS LIST

PART		STREET PRICE
CASE	FRACTAL DESIGN NODE 304	\$139
MOTHERBOARD	GIGABYTE H97N-WIFI	\$170
CPU	INTEL PENTIUM G3258 AE	\$95
MEMORY	CRUCIAL BALLISTIX SPORT DDR3 @ 1,600	\$98
GPU	INTEL HD GRAPHICS	\$0
PSU	CORSAIR RM 650X	\$169
STORAGE 1	KINGSTON SSDNOW V300 120GB	\$79
STORAGE 2	HITACHI ULTRASTAR 2TB HDD 7,200RPM	\$80
TOTAL		\$830

G4400, a Samsung SM951 for boot drive, and a Gigabyte GA-Z170N ITX motherboard or equivalent (remember to make sure it supports the M.2 connection standard).

"We stuck with the retail cooler — unless you're planning on overclocking the Pentium G3258, you can get away with retail."



1 DDR AND PROCESSOR CHOICES

In a build like this, processor choice is one of the few decisions you're going to have to make early on. The Intel Pentium G3258 AE is a marvel, capable of punching out hefty overclocks up to 1GHz over stock — if you've got the cooling capacity. The retail cooler leaves quite a bit to be desired, but finding suitable cooling solutions in the Node 304 is challenging. Even Corsair's compact Hydro AIO doesn't quite fit here. But this is a very basic home theater/streaming PC, so do you really need the extra grunt in a machine like this? On top of that, you have to consider what RAM you're going to use. We decided to crack out this set of Crucial super low-profile DIMMs, providing us with 16GB of DDR3. They're a little antiquated by today's standards, but are still overkill for what we intend to do with this build.

2 PCIE WOES

So the ITX form factor, while pleasingly compact for our aesthetic requirements, allows itself the luxury of just one PCIe slot. That's enough for one graphics card, a soundcard, or some form of PCIe add-in card. Unfortunately, the Fractal Node case doesn't give you much in the way of room for manoeuvre. Once you have the power supply installed, along with a couple of hard drives, fitting a GPU around the cables in the Fractal Node is damn near impossible. In fact, this is the only time that we've found a suitable application for the tiny footprint of AMD's R9 Nano. The reason we bring this up is mostly down to the troubleshooting we had to go through just to get that Pentium G3258 to work once the system was put together. But we'll touch on that in the conclusion...



3 POWER SUPPLY PROBLEMS

As you can see, this build is messy. Very messy. Unfortunately, the Node's low-slung design leaves little room for any form of cable management. Even with an infinite number of cable ties, it's a struggle to tidy this up effectively. And that's not the end of the problems: If you ever fancy transforming this spec into a gaming system, your GPU choice is going to be substantially limited. In fact, in a lot of ways, you'd be better off purchasing a non-modular PSU. The reason we say this is because most non-modulars have all their cables bunched up in one corner — as opposed to laid out and nicely organised along the back of the power supply — which saves space, and hopefully helps you install your GPU with as little trouble as possible.



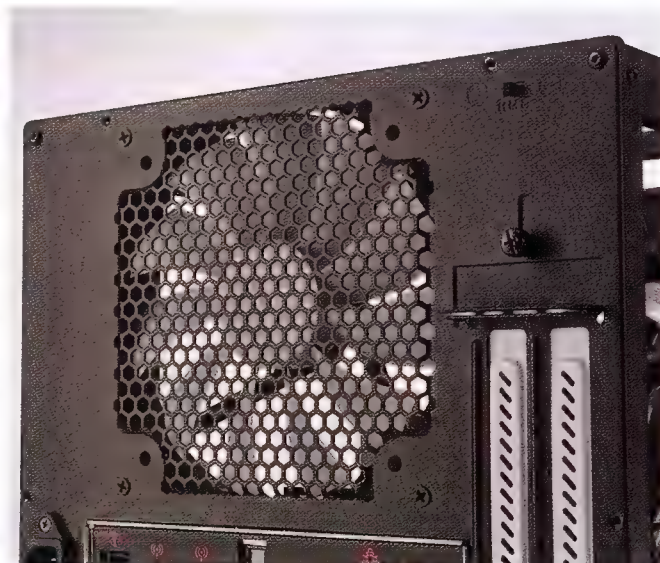
4 PASS-THROUGHS AND COOLING

Because the power supply is situated at the front of this build, we have to make do with a substantial pass-through, heading along the side of the case. It doesn't cause much in the way of problems, but it's worth remembering that you'll need to leave the power switch on here before closing up your chassis. There's nothing worse than closing up a chassis, plugging everything in, and then scratching your head, wondering why it isn't powering up. Also, you can just about glimpse those dual 92mm intake fans at the top there. They're mighty quiet for fans of this size, yet still provide plenty of oomph when it comes to internal cooling.



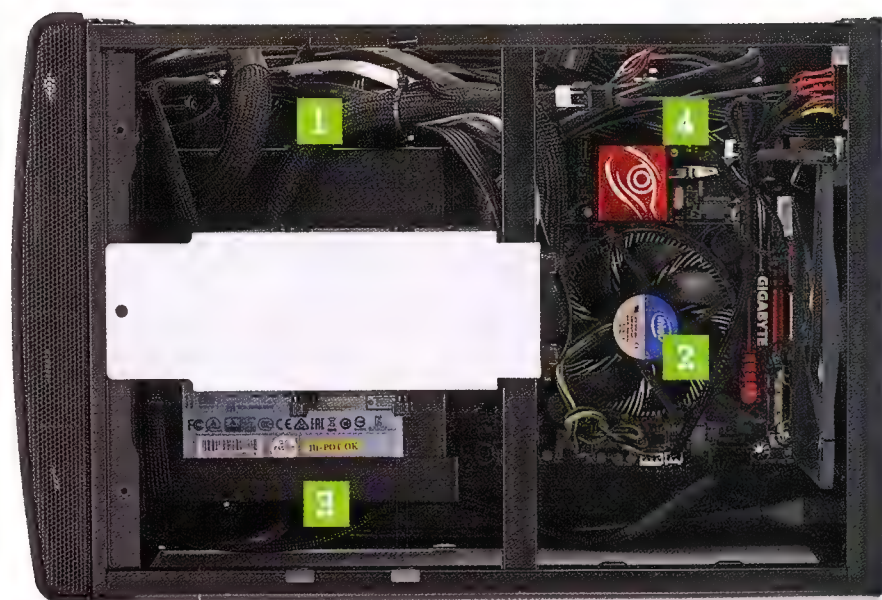
5 HARD DRIVE CADDIES

One of the neat features Fractal included in the design of its Node 304 is these sweet little drive cages. Capable of mounting two drives in each, these sit snugly in the top of your chassis, along a cross-member support pole. Three come as standard with the case; we opted to use one, and slapped it right in the middle, between the two fans, and removed the two extraneous cages to improve internal airflow. Each caddy comes with rubber grommets for spinning hard drives, and traditional mounting points for SSDs. Just remember to orient your drives the correct way round when installing them, so your connectors are facing away from the end of the Fractal logo.



6 EVEN MORE COOLING

That's one meaty 140mm fan in the back of the chassis. We reoriented it so it's drawing air into the chassis, as opposed to pumping it out. Ideally, it may have been better to see whether we could attempt to mount a single AIO cooler in here, but to keep the cost down, we opted to go with the retail cooler instead. There's also an exceptionally simple fan controller located on the top-right, too, just above the PCIe brackets. It comes with three settings — low, medium and high — and three headers internally, for the three fans powered by a single Molex adapter.



1 This cable management hell wasn't particularly enjoyable to work on. In fact, a non-modular PSU might have provided us with more room to maneuver.

2 Fitting an AIO cooler to replace the stock one might have been a good move, especially if we were overclocking, but it would have ramped up our budget significantly.

3 Pass-throughs are certainly handy in a chassis like this, but for the sake of a GPU, we would have loved to see the pass-through on the other side, and the PSU reversed.

4 Molex — why, oh why do you exist? No, really. Plugging the Molex power into the fan controller here was a total nightmare.

"The build process was excruciatingly frustrating — impressive, when you consider how little there is in the system."

Streaming PC success?

So have we achieved a system capable of streaming content across wireless networks at HD and UHD? Yes. Amazon Prime, Netflix and YouTube all work seamlessly at 2,560 x 1,440, delivering top-notch content in your own home. The Pentium G3258 is fairly beefy when it comes to streaming content at this resolution, and in everyday desktop operation, there's very little difference between this and the likes of an Intel Core i7. However, we live in the age of 4K TV — 1080p is the new CRT, and a maximum resolution of 60fps 1440p just doesn't cut it.

Your best bet for a 4K streaming rig is to opt for more modern hardware in the form of Skylake and the Z170 chipset. We had a soft spot for the Pentium G3258, due to its overclocking capabilities. Even so, you can add all the MHz in the world, but if the chipset and integrated GPU don't stack up, what's the point? We should have opted for one of Intel's newer G4400 Pentium dual-core CPUs. You could put together a similar system using more modern components for around the same price, at a spec that would make mincemeat of 4K streaming. Hardware struggles to hold its value second-hand, yet as a year or two passes, it becomes far more expensive to buy brand new. You could forge a system out of spares and old parts (which is what we're suggesting), but you'll be far better off opting for newer in-stock gear, as opposed to buying out-of-date hardware.

The build process was excruciatingly frustrating — impressive, when you consider how little there is in the system. The RM650X, although fantastically quiet, doesn't do so well in a small form factor case. The lack of cable management space really did a number on us. This case would've worked much better if the power supply orientation was reversed, and the power pass-through located on the side of the PCIe slot, so we would have the choice of installing a GPU.

On top of that, during installation of the OS, we encountered numerous problems, mostly due to an uncleared motherboard leading to a multiplier of 46 being applied to the G3258 core. Amazingly, even at 4.6GHz, it was stable, but the temperatures kept ramping up when we tried to extract zipped files, to the point that the

system would hard reset to protect the core. On top of that, fast-boot was enabled, and getting into the BIOS without a dedicated GPU was nigh-on impossible. In the end, we had to use Intel's Extreme Tuning Utility, and install a spare GPU in the form of the R9 Nano to get back in.

In hindsight, we would have loved to have gone for a more impressively specced Skylake rig, but for a system that we pieced together out of spare parts and older components, it shows just what you can do with old tech.

As a final disclaimer, we should point out that this isn't going to break any records when it comes to benchmarks — it's not meant to. It's a perfect office PC, a system for your grandma or a home theater. It's never going to be a bank-busting, frame-rendering, zero-point-shredding machine. ■

BENCHMARK RESULTS

	APC LABS TEST PC	THIS SYSTEM
CINEBENCH R15 MULTI THREAD	987	226 (-77%)
CINEBENCH R15 SINGLE THREAD	196	117 (-40%)
TECHARP'S X264 HD 5.0.1 (FPS)	21.93	6.28 (-71%)
PC MARK 8 CREATIVE	7,675	2,864 (-62%)
CRYSTALDISK SEQUENTIAL READ (MB/S)	1,895	508 (-73%)
CRYSTALDISK SEQUENTIAL WRITE (MB/S)	949	107 (-88%)
RISE OF THE TOMB RAIDER (FPS)	41	2 (-95%)

Our APC Labs system uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM. All games are tested at 1080p on max settings, with HD texture packages installed.

Create a one-time pad with a Pi

Nate Drake explains how your Pi can bring you to the very pinnacle of cryptography by exchanging messages in perfect secrecy.

Quantum Computers. Microphones so sensitive that they can record your keystrokes from yards away. Networks of zombie computers working round the clock to brute-force passwords. Government designed backdoors in code. It has never been harder to be entirely certain that any message you send can be transmitted or received in absolute secrecy.

This holy grail of cryptography has long frustrated security experts, and most people are willing to settle for using encryption programs like gpg, which, while theoretically breakable, will resist all cracking attempts long after you're pushing up the daisies.

What if, however, there was a way to be certain that your personal emails, pictures of your pet kitten, backups of your tax returns for the past decade and so on were safe even if intercepted? Enter the One Time Pad.

THE NOTORIOUS OTP

In simplest terms, a One Time Pad is a series of random numbers which you agree upon with someone with whom

you wish to communicate – usually by meeting in person and exchanging pads.

When sending a message, you first need to convert it to numbers, then add each of these numbers to the numbers in the pad. Once the recipient receives the message, they can work backwards using their copy of the pad, deducting the numbers to retrieve your original written message.

Provided that the numbers are truly random, no one else sees the pad, and the same text isn't encoded twice with the same pad, then even the world's fastest supercomputer couldn't decode the message.

The strength of the encryption lies in the randomness of the pad numbers. Without knowing these, anyone who intercepted a message might see the word 'LINUX' encrypted as 'OSYAJ' but would have no way of knowing it isn't another five letter word, like 'CHILE'.

The One Time Pad has been kicking around in some shape or form since the 1880s but it wasn't until 1917 that Gilbert Vernam et al formally patented a machine for automating the process.

In this case, two reels of punched tape were used, one with the original message and one with the pad of random numbers.

KGB agents in the US were quick to exploit this during the Cold War, placing small pads inside hollowed-out nickels, fake walnuts and any number of dastardly hiding places.

In the 21st century, computers like Raspberry Pi lend themselves well to being carried around easily and are perfect for generating and processing One Time Pads.

But in order to understand why, it's necessary to understand the pitfalls of the One Time Pad.

ENTROPY ISN'T WHAT IT USED TO BE

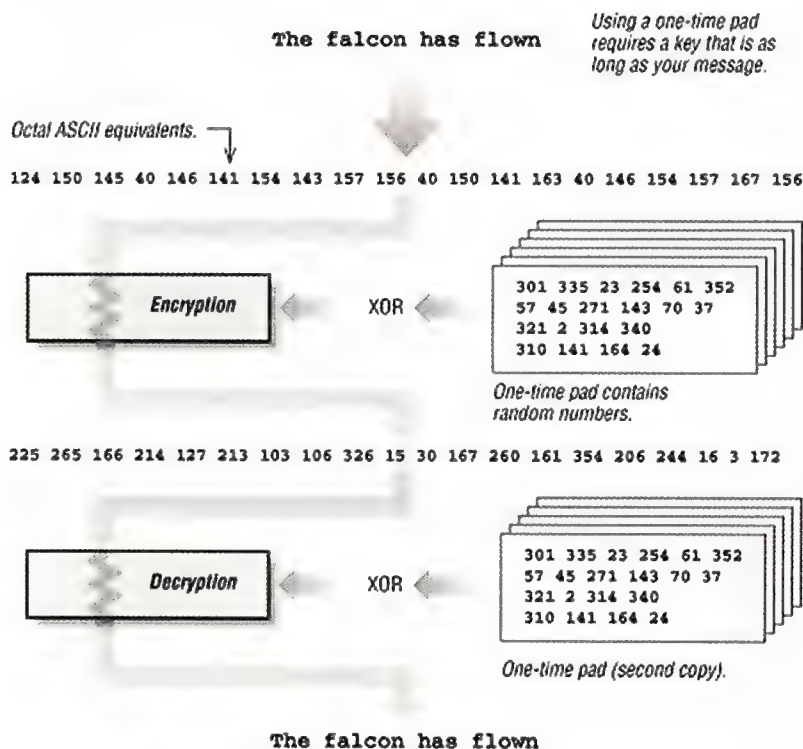
Bruce Schneier once described the One Time Pad as "theoretically secure, but... not secure in a practical sense". This reflects the fact that there have been times that OTPs have been broken in practice despite their theoretical security. In the 1940s, for instance, US SIGINT's counterintelligence program Venona was able to decrypt a number of Soviet OTP messages simply because some pads had been reused.

This crypto-cardinal sin was committed because the Soviets simply couldn't generate pads fast enough for the thousands of daily messages sent during wartime.

A similar chink is found by German codebreakers in Neal Stephenson's *Cryptonomicon*. The British employ a raft of old ladies with small bingo machines to draw numbered balls to generate pads. Unfortunately, the old dears don't always obey best practices – they fail to look away each time they draw a ball as instructed, meaning that they subconsciously select predictable numbers.

Fast forward to the 21st century and the issue hasn't improved much. Entire books have been devoted to this subject but suffice it to say that computers generally aren't very good at generating true randomness. Usually when it's required, a website or program will ask you to wiggle your mouse to provide a so-called 'noise source' to work from.

Mostly, however, when a computer requires larger amounts of randomness, it will form a string of pseudo-random data from your entropy pool, which, while ideal for determining where the



One implementation of the OTP encoding the message "The falcon has flown." You'd be quackers not to use it.

OTP goes Thermal

In order to proceed, you'll need to have your Adafruit Printer set up and working. Fortunately, the website has an excellent guide to this available at learn.adafruit.com/mini-thermal-receipt-printer.

First, install rng-tools as indicated in Step 1 of the walkthrough on page 99. You'll also need to edit /etc/default/rng-tools in your favourite text editor. Remove the # at the beginning of the line `HRNGDEVICE=/dev/hwrng`. Save and exit.

Use `sudo /etc/init.d/rng-tools restart` to be certain the Pi is using only the hardware RNG now.

Next, download the otp-gen software: `git clone https://github.com/iworkinpixels/otp-gen.git`

At this stage, if you wish, you can go into the `otp-gen/` folder and run off a

sample pad to see what it looks like:

```
# cd otp-gen
# sudo ./otp.py
# nano otp.txt
```

Next, we need to make sure the software starts automatically when the machine starts:

```
# sudo nano /etc/rc.local
```

Scroll to the bottom of this file and insert the following three lines above the words 'exit 0':

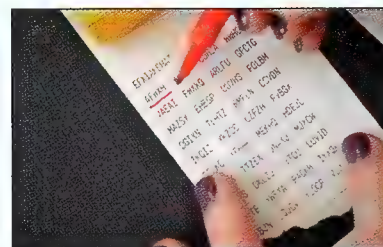
```
# cd /home/pi/otp-gen
# ./otp.sh
# python ./otp.py
```

If you have downloaded the `otp-gen` folder to anywhere else besides `/home/pi/` then change the first line accordingly.

Use Ctrl-X to come out of the text editor, and press 'Y' to save the changes.

Next use `sudo reboot` to restart

your Pi. The printer should print out a message saying it's connected to the network along with your IP address, then pause. Simply press the button to generate your own one time pad. Repeat as many times as you like.



Sample printout of an OTP. It's a good idea to leave the first five characters unencrypted so it's easy for your contact to know where to start.

next block will fall when you play Tetris, is less than perfect when it comes to security.

Thankfully one of the lesser known features of the Raspberry Pi is that it has its own built-in hardware random number generator, which, in combination with the `rng-tools` suite, can generate exactly the kind of high-quality randomness needed for an OTP.

The second obstacle faced by those using OTP has to do with key generation and distribution. The Soviets were unable to keep up with the demands of war, and in real life, the bingo machines of Britain's little old ladies would probably end up smoking with the number of times they'd need to be churned.

Fortunately, the hardware RNG built into the Pi can generate large amounts of data in a short amount of time. For instance, a pad with 10,000 sets of five-digit random numbers can be generated in seconds by activating the hardware RNG (see Step 1 of our guide on page 99) and then entering:

```
# sudo base64 /dev/hwrng | tr
-dc '0-9' | fold -sw 5 | head
-c 10000 > bobtoaliceotp.txt
```

The resulting text file can then be printed out, for instance by Adafruit's thermal printer. This printer has the advantage that, unlike most laser printers, it doesn't record the serial number, make or model on each sheet it prints out (on this, see www.eff.org/issues/printers). It also holds up to 15m of paper, which will be plenty for generating long messages. Using this in combination with the excellent program `otp-gen`, you can print off your

own pads automatically at the touch of a button too (see the 'OTP goes Thermal' box above).

Once the reams of paper are safely printed and tucked away, next comes the issue of physically distributing pads. This is no doubt the main reason why the OTP hasn't seen much widespread use. It's rumoured that the red phone running between Washington and Moscow for instance is secured by an OTP, mainly because both Superpowers are wealthy and melodramatic enough to have men with dark glasses to handcuff themselves to briefcases and swap pads at regular intervals.

Of course if you have printed paper pads, it is possible to mail them to your recipient, but then your OTP would be no safer than a regular letter because it may have been intercepted and copied along the way. The same applies for

using regular encryption programs like GnuPG.

The only way to be sure that your pad cannot be intercepted is to deliver it in person. Again the humble Raspberry Pi comes to the fore here because it's extremely small and easy to carry. Upon meeting the person with whom you want to exchange messages, you can give them a copy of your Pi's microSD card or the Pi itself.

To ensure perfect security of your messages, it's necessary to delete pads that have previously been used. If you have printed yours out, a little tearing off and a Zippo lighter is likely to be helpful here. (Other lighters are available.) Otherwise running the `shred` command on the pad you just used should be enough to prevent recovery.

Both SD cards and Pis are inexpensive also, so if you really feel you have to destroy them once the pads



A hollowed-out nickel and microfilm as used by the KGB. The Kremlin awarded Brownie points to Soviet spies who didn't accidentally spend them.

have changed hands, you can do this as well.

The low cost of a Pi is also a great answer to another common criticism, which is that an OTP is usually very difficult to scale beyond two people exchanging messages. If you do decide to form a secret society, it may be best to designate one person to meet each member and exchange pads regularly. That person can then sit at the centre of the web and act as a clearing house for messages, forwarding them between members as need be.

Even using a Pi, however, it is still possible for pads to be intercepted, and communicating can be cumbersome. This is why it's good to employ some best practices for your OTP.

SUPERSIZE YOUR OTP

For pen and paper OTPs, although technically it's possible to convert each letter to numbers (A = 1, B = 2, etc) and then add them to the numbers in the pad, this can be rather cumbersome and it doesn't allow you to send any special

characters. One very easy way around this issue is to write a message on your Pi and then combine it with a block of random data using Karl Fogel's excellent program OneTime, as explained in the walkthrough on the next page.

If you prefer going old-school, Russian spies used to use a device called a straddling checkerboard to avoid long nights struggling with walnut shells. Search online for an image of this and you'll see that, although there's a lot of variations, the most common letters are typically along the top row, which means they can be enciphered as a single digit. Less common letters are represented by their row and column — for example, the letter C is represented by the number 21. This also allows special characters such as 62, which switches between letters and numbers. The alphabet can be rearranged in any order you like for extra security if you wish.

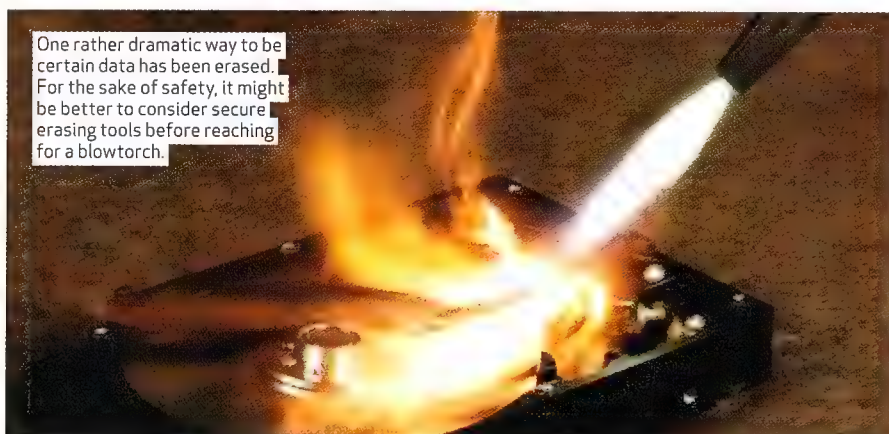
Another way to save on scribble time is to borrow a trick from thrifty business owners in the 1800s by using

Questions.		SHIPPING.		Pop.	
No.	SENTENCES.	No. of Cipher Word.	No.	Cipher.	No. Rep.
3139	What vessel did you ship by?	3139	Poplial		
3140	When, how, and by what route shipped?	3140	Forage		
3141	When and how were bills of lading forwarded?	3141	Forbade		
3142	When can you ship?	3142	Forbear		
3143	When will a sailing vessel clear for—?	3143	Forbid		
3144	When will you ship?	3144	Forbidden		
3145	Which did you ship?	3145	Forable		
3146	Who are the consignees?	3146	Forego		
3147	Will a few days delay in shipping make any difference to you?	3147	Forenoon		
3148	Will you receive consignment of—?	3148	Forelock		
3149	Ship	3149	Foremost		
3150	Additional	3150	Forest		

From *Bolton's Commercial Cryptograph: a telegraph code and double index holocryptic cipher*. Given the purpose of the book, you'd think it would have had a shorter title...

codes for common words and expressions — to avoid having to pay for long messages, Bolton's Telegraph Code for example uses the number 0446 to represent the classic excuse, "The cheque was sent to you in the last post." Sadly, there is no corresponding code for, "It was like that when I got here."

Books like Bolton's aren't meant to disguise the meaning of what you say, just to save time. However, if you are going to the trouble of meeting and exchanging keys with a friend, there's no harm in deciding together your own code names for common people and places. For instance, if the members of your secret society regularly meet by a weeping willow in Hyde Park, you might decide to refer to that location as "Sweden" and to refer to each of the members using animal names. This would mean that if the decoded message "Meet me with Penguin in Sweden" is intercepted, shadowy government spooks will be left scratching their heads. As you meet



One rather dramatic way to be certain data has been erased. For the sake of safety, it might be better to consider secure erasing tools before reaching for a blowtorch.

Max out your MAC

It's best before sending any private information with an OTP to send a Challenge-Response message first. Technically, you could agree on two code words to use with your recipient: one could indicate that it's you and you're able to talk freely — for example, "Everest" — and another could disclose that you're talking under duress — for instance, "Sparrow". This means, however, that the same text is being encrypted each time, making messages easier to crack.

A better system is to choose from a list of prearranged words or phrases. One way to do this would be to agree on a book — directories and almanacs are perfect types of book for this — and in your 'challenge' message, you could send an arbitrary page and line. For example

you could agree to use the 1992 edition of Wisden Cricketer's Almanack. Bob can message Alice saying, "613-1." Alice can reply with the first line of page 613, which is:

"Worcestershire were the only county to win two trophies in 1991."

She can then add a challenge of her own to the message, for example asking for page 582, line 4.

If, of course, Alice replies with anything other than the correct words, Bob will know that it's not her or she's under duress, and the same applies with his reply to her. You can further increase the security of this system by agreeing beforehand that the response to the challenge should not be the line requested in the message but the one (say) three lines after, or perhaps the same line on the following page.



If you insist on using a printout, a few pearls of Wisden can't hurt.

to exchange more pads, you can then decide on code names for new people and places.

Any OTP system is only as good as the security of the pads, so regardless of whether you use a computer program or paper, it's important to destroy both the pad and your 'plaintext' message once you have sent a message and both the pad and the 'ciphertext' message once you've decoded any message you've received.

If you use the OneTime program in combination with a large file of random data — say, 1GB — the program will only use as much data as is needed to encode your files — so a 128K PDF will only be around 128K in size.

Each encoded file records the offset in bytes of those used in your pad, so your contact's version of OneTime will be able to decode it. Drawing on one very large file, however, means you cannot delete pad data no longer in use without removing the entire file. This is why it's best to split your large file of random data into multiple smaller chunks, which you can delete regularly.

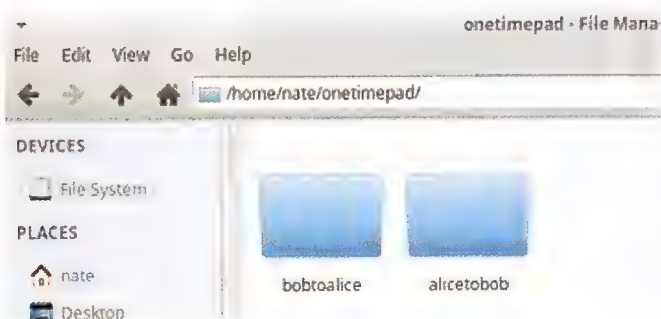
By default, OneTime will prevent you from encoding files with the same random data. See the walkthrough below for more information on this.

OTP also doesn't have any built-in way to make sure that the person you're talking to is the person to whom you gave the pads. If you're using your Pi to

send and exchange messages, it's best to use gpg to digitally sign any messages you send. If you're using pen and paper, you can use a less secure form of Message Authentication (See 'Max out your MAC' on the previous page).

Finally, there is no reason that you can't use OTPs in combination with other forms of security. For instance, you can encrypt a zip file with a ridiculously long password and send just the password via OTP instead of the whole message. In particular, the OneTime program encrypts files in text format, so you can place these files on a password-protected drive also to boost your security. Feel free to experiment and decide if this is right for you.

Use digital One Time Pads



1 INSTALL ONETIME AND CREATE FOLDERS

The OneTime application is available as part of the Debian jessie repository — simply run the following:

```
# sudo apt-get install onetime
```

If you're using the Adafruit printer, you'll also need rng-tools:

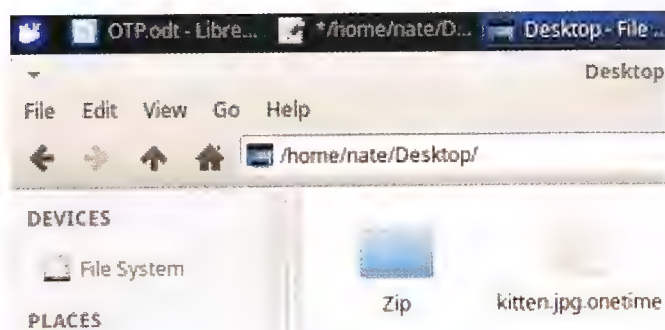
```
# sudo apt-get install rng-tools
```

At this stage, you may wish to create a folder for your pads:

```
# mkdir -p onetimepad/{bobtoalice,alictobob}
```

Use cd to go to the first folder, for example:

```
# cd home/pi/onetimepad/bobtoalice
```



3 ENCRYPT YOUR DATA WITH OTP

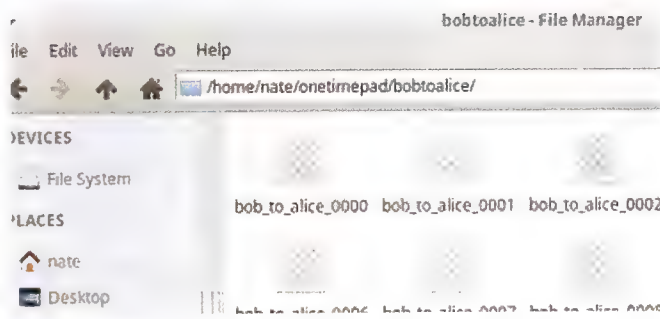
OneTime has a simple format for encoding files:

```
# onetime -e -p ~/pathto/your.pad yourfile.ext
```

So, for example:

```
# onetime -e -p ~/onetimepad/bobtoalice/bob_to_alice_0001 ~/Desktop/kitten.jpg
```

(The file must be smaller than the pad.) You'll see alongside the original file a file with the same name and the .onetime extension. Make sure to run the shred command on the pad you just used and the original file.



2 GENERATE RANDOM PADS

The following commands create a 10MB block of random data, and splits it into numbered 1MB chunks, named bob_to_alice_0009 and so on. Feel free to change the numbers:

```
# sudo dd if=/dev/hwrng of=bob_to_alice.pad bs=1000 count=10000
```

```
# sudo split -b 1000000 -d -a 4 bob_to_alice.pad bob_to_alice_
```

```
# sudo shred -uz bob_to_alice.pad
```

Repeat this for the "Alice to Bob" pad. Give your contact a copy of both pads.



4 DECRYPTING OTP MESSAGES

Once 'Alice' receives your message and has installed OneTime, the command to run is simple, provided she has a copy of the same pads:

```
# onetime -d -p ~/pathto/your.pad yourfile.ext
```

So in the example case we're using:

```
# onetime -d -p ~/onetimepad/bobtoalice/bob_to_alice_0001 ~/Downloads/kitten.jpg.onetime
```

The decrypted file will appear in the same folder as the .onetime file. 'Alice', in turn, should be sure to run the shred command on the pad and the encrypted file once decoded. ■



More Android USB charging secrets

With new power delivery standards and attacks from malware-embedded USB chargers, Darren Yates reveals how to get your phone charging faster and safer.

Batteries are one of the many technology devices we all take for granted – that is, until they go flat, or in the recent case of Samsung's Galaxy Note 7 smartphone, they're the subject of a potential safety risk and result in a global product recall. Smartphones don't work without batteries, but as each new generation of phone gets bigger and faster, we're becoming more impatient, demanding batteries that last longer and charge faster.

A couple of years ago, we took an in-depth look at how Android USB charging works (tinyurl.com/oe7lmm8). Since then, the landscape has changed considerably to include new power delivery standards and concerns over rogue USB chargers injecting malware into phones – time enough for us to uncover more Android USB charging secrets to share.

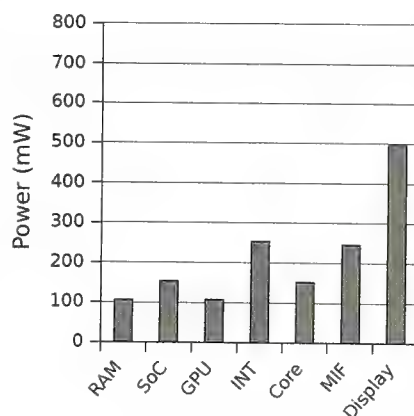
THE PROBLEM

While SoCs (system on a chip) continue to become more power-efficient through reduced-scale manufacturing, the real problem is the major cost in

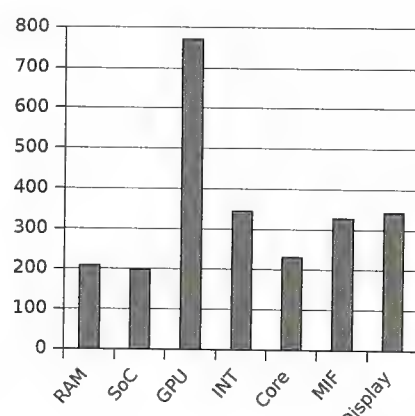
electrical power draw is still the screen. And as screen sizes continue to grow, battery capacity also has to scale to achieve at least comparable run times to previous smaller-screened models.

Back in 2013, researchers Aaron Carroll and Gernot Heiser of the

University of New South Wales carried out power consumption experiments on a Samsung Galaxy S3 smartphone, measuring power usage of various components within the phone (www.nicta.com.au/pub?doc=7044, PDF). The results showed that whether the phone was idle or playing *Angry Birds*,



(a) Angry Birds

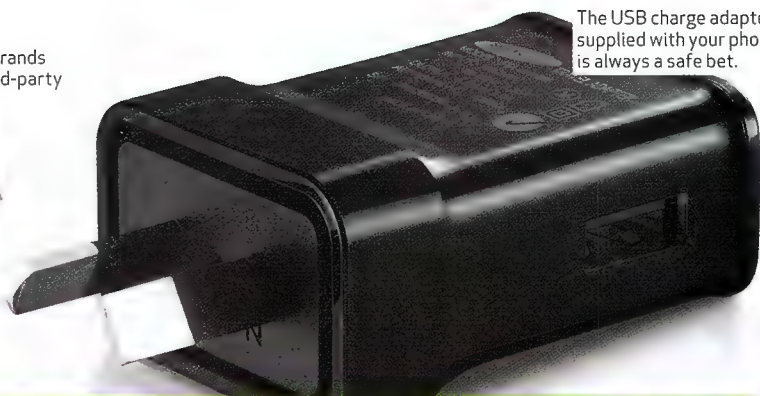


(b) Need for Speed

Galaxy S3 power draw during gaming. (Source: Aaron Carroll)



Stick to known brands when buying third-party chargers.



The USB charge adapter supplied with your phone is always a safe bet.

"By the time the USB standard caught up, we had two new port specifications — the Charging Downstream Port (CDP) and the Dedicated Charging Port (DCP)."

the screen was the most power-demanding component (you had to play a 3D game like *Need for Speed* before the GPU took over that mantle). Now, as screen sizes have increased, so too have battery capacities. The 3.7-inch HTC Desire, the Android phone to own back in 2010, came with a 1,400-milliamp-per-hour (mAh) Lithium-ion battery. The new 5.5-inch Samsung Galaxy S7 Edge features a 3,600mAh battery — more than two-and-a-half times the capacity. LG's new mid-range X Power phone packs in an even larger 4,100mAh battery.

While larger batteries are great for run-times, they're not so great for charge times — unless you employ some radical charging techniques. But unless you're also aware of how new USB charging specs work, you could be charging your phone at below-optimum rates, or worse, putting your tech in harm's way.

USB CHARGING STANDARDS

Let's face it — to many, talking about USB charging standards can be as boring as watching paint dry. But if

you're the type that goes out and buys a \$1,300 smartphone, then pairs it up with a cheap charger from a \$2 shop, you could be in for a real shock.

Read our original 2014 story online for the basics of USB charging — some sections of that story are still relevant, others are now out of date, hence this update. Just remember that, as a result of continual development, multiple charging standards now exist for smartphones over USB — whether via a PC port or a dedicated AC USB charger.

Going over the basics just briefly, the original USB1.0 standard allowed a device charge rate from a USB port of 150 milliamps (mA). USB2.0 pushed that to 500mA and USB3.0 to 900mA. Eventually, special battery charging specifications arrived to boost the charge current from spec'd-up ports to 1,500mA. The problem was that smartphones arrived before the new specifications did and manufacturers being an impatient lot, they came up with their own standards involving voltage-level sensing on the D+ and D- lines in the USB wiring. With this technique, Apple created three

different charge rates — 500mA, 1,000mA and 2,100mA to suit various iPhones and iPads.

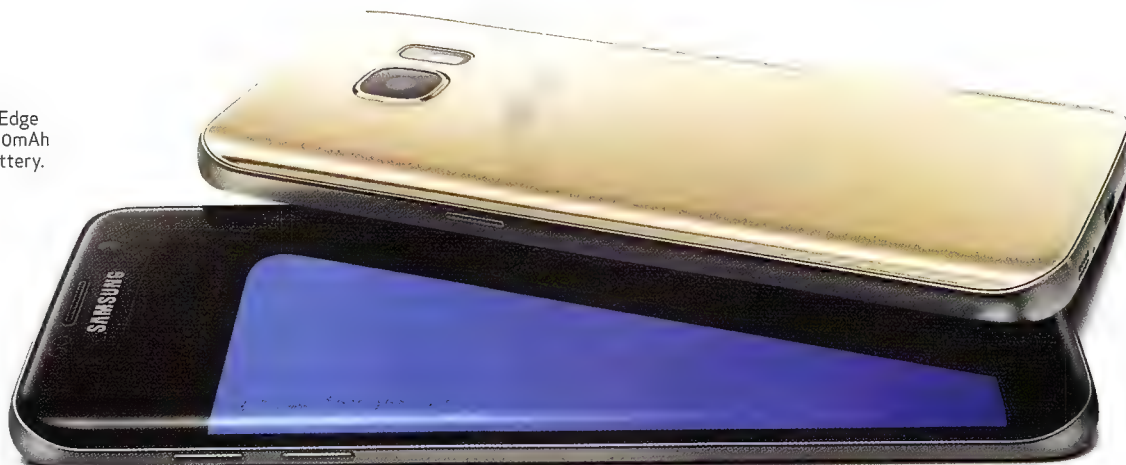
By the time the USB standard caught up, we had two new port specifications — the Charging Downstream Port (CDP) and the Dedicated Charging Port (DCP). Both of these offer charge rates of up to 1,500mA — a CDP also supports data transfer, but a DCP doesn't. Backwards-compatibility generally ensures safety for devices and charging ports.

ACCELERATED CHARGING

Since then, the USB charging landscape has changed dramatically — much of it because battery capacities keep rising. As before, manufacturers have taken matters into their own hands and come up with a series of mostly-compatible, non-standard accelerated charging technologies. Samsung has 'Adaptive Fast Charging', HTC sells 'Rapid Charging' and Motorola 'Turbo Charging'.

For the most part, these are based on chipmaker Qualcomm's 'Quick Charge' technology baked into many of its later Snapdragon SoCs, but licensed to other

The Galaxy S7 Edge packs in a 3,600mAh Lithium-ion battery.





Beware, not all Type-C to Type-A USB cables are within specifications.



Google's own Type-C charger for its new Pixel and Pixel XL phones.

makers as well. Up until now, USB charging was all about how much current you could suck through a USB cable at a fixed 5VDC voltage level. Qualcomm then thought, 'What if we jacked up the voltage instead?' and Quick Charge was born.

Quick Charge 2.0, the standard the others have licensed, supports three voltage rails on 'Class A' devices like smartphones – 5VDC, 9VDC and 12VDC. Quick Charge-ready charge adapters and phones negotiate the optimum power levels to suit conditions. New Quick Charge 3.0 replaces the three voltage rails with a voltage system that dynamically switches between 3.6V and 20V at 0.2V increments. Qualcomm says charge times can be as much as four-times faster and phones with Snapdragon 430, 617, 618, 620 and 820 SoCs can be Quick Charge 3.0-ready (provided the charger and cable are also spec'd right).

USB3.1 AND USB-C

But it's the arrival of two new contestants – USB3.1 and USB-C –

that have blurred the lines more so. Some may suggest to you these two are the same thing – unfollow them immediately. USB3.1 refers to a group of new USB specifications, whereas USB-C, which we'll insist on calling 'USB Type-C' from here on in, is the new reversible USB connector.

USB3.1 has taken over the specification of USB3.0 to such an extent that USB3.0 is now known as 'USB3.1 Gen1' and what we called 'USB3.1' is really 'USB3.1 Gen2'. That's not confusing at all. USB Type-C connectors are designed to support the USB3.1 family standard of data transfer at up to 10Gbps, as well as support the current USB Power Delivery Rev 2.0 (PD) v1.2 standard.

The USB PD2.0 v1.2 spec is a standard for powering devices over USB and supports four voltage rails of 5, 9, 15 and 20VDC. There was some talk of phone makers looking to see how Power Delivery 2.0 would line up against Qualcomm's Quick Charge. However, things get tricky around USB Type-C connectors. Google engineer

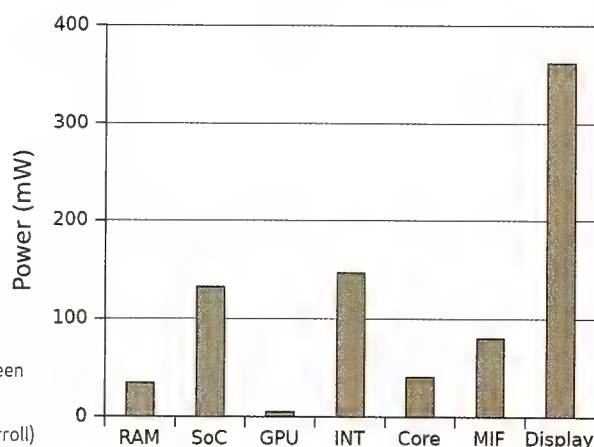
Benson Leung has become something of a champion of USB Type-C and USB3.1 standards and he's not particularly fond of running Quick Charge 2.0/3.0 over USB Type-C. In fact, he cites sub-section 4.8.2 of the Type-C specification, which declares devices charging over USB cannot "redefine" the "Vbus" USB voltage beyond the USB2.0/3.1 specifications, as to why he believes Quick Charge 2.0/3.0 on USB Type-C violates specifications (tinyurl.com/h38gcpa). Qualcomm reportedly responded to these concerns with a statement published on AndroidCentral, which essentially says that Quick Charge was designed to be connector-independent and that manufacturers can configure Quick Charge to be within Type-C specification (tinyurl.com/jh8mdfv).

Charging your smartphone is not quite as simple as it seems.

THE SILENT KILLERS

But it gets worse. We all have USB2.0 cables by the bushel. However, when it comes to USB Type-C, USB cables become a far more dangerous problem involving what we'd call the 'silent killers' – certain USB Type-C to USB Type-A cables that do not meet specification and could easily blow up USB Type-A ports when charging Type-C devices.

The problem occurs when a USB Type-C device wishes to pull 3,000mA of current from its charging port. If the cable doesn't include the correct 56kohm pull-up resistor to identify it as a Type-A legacy cable, the device being charged will assume it's connected to another Type-C port and try to drag 3,000mA of current out of it. Meanwhile, the Type-A port on the other end, which will be lucky to deliver 1,500mA of current downhill with a tailwind, starts gasping for air and eventually blows up under the immense strain.



The Galaxy S3 screen dominates power draw at idle. (Source: Aaron Carroll)

Figure 3: Idle power in airplane mode. $P_t = 805 \text{ mW}$.



Inline USB volts-amps meters can show power draw from USB ports.

If you stick to the cable and charger supplied with your USB Type-C device, everything should be sweet. But obviously, if you purchase a USB Type-C to USB Type-A legacy cable to charge from or connect to some other device, such as a PC or notebook USB port, you need to choose carefully to avoid meltdowns. And unfortunately, more than a few non-standard Type-C to Type-A cables have hit the market (tinyurl.com/hmydg4s).

HOW TO TEST LEGACY TYPE-C CABLES

If you're concerned about a third-party Type-C to Type-A cable, you can test it yourself if you have a Nexus 6P or 5X smartphone. On a Nexus 6P, plug the Type-C end into your phone, launch a Terminal shell on your phone and enter:

```
cat /sys/class/typec/typec_device/current_detect
```

If the answer comes back '2', the cable is out-of-spec ('2' indicates 3,000mA). For Nexus 5X phones, do likewise, but type on the shell:

```
cat /sys/bus/i2c/drivers/fusb301l/*fclientcur
```

If you get the answer '3,000', again, the cable isn't right (tinyurl.com/hwj2uym). There's also a free app on the Google Play store called 'CheckR' (tinyurl.com/zab8kcc), although at time of writing, an update was still to arrive for Android 7.0/Nougat devices and still only worked with the Nexus 5X and 6P phones.

In any case, any phone that's USB Type-C-compliant should be looking for that 56kohm resistor inside the cable that identifies it as a Type-A legacy cable before setting the maximum charge current appropriately. If that

resistor isn't there or is the wrong value, look out.

NEW USB POWER DELIVERY 3.0

Now aside from Type-C cables, issues have also been detected with some USB Type-C charge adapters. So the USB Implementers Forum (USB-IF) has launched a new certification program for Type-C chargers. There's also a new Power Delivery Rev3.0 v1.0a standard (tinyurl.com/powerdev), which should go a long way to fixing up these issues. According to the USB-IF, PD 3.0 is "functionally the same" as PD 2.0 v1.2; however, it will include a new 128-bit cryptographic-based authentication system for both chargers and devices. The new system will allow Type-C charger's capabilities and certification status before any significant electrical power changes hands (tinyurl.com/jl9g5sp, PDF).

MALWARE CHARGER ATTACKS

The authentication process certainly makes sense. But if you're wondering why the USB-IF has implemented 128-bit encryption in what seems to be little more than a quick handshake between electronic components, it also aims to protect USB Type-C devices against malware attacks from either rogue charge adapters or public charge terminals. The idea is that the encrypted authentication allows phones to implement security to only charge from certified chargers.

HP recently found itself on the wrong side of social media when a new software update blocked some non-authenticated third-party printer cartridges (tinyurl.com/j497suq). Some might argue certified chargers are just another shade of the HP issue. However, the need to protect not just against out-of-spec electronics but

malware chargers as well all but makes it a necessity.

And this isn't a pie-in-the-sky kind of problem either — the malware-riddled USB charger concept has been around since at least 2013, when researchers from the Georgia Institute of Technology first unveiled the 'Mactans' proof-of-concept malware charger (tinyurl.com/ny5l64c). At the time, it was a big deal for iOS because no jailbreak was required — the hack happened automatically as soon as the fake USB charger was connected, there were no obvious signs your phone was being hacked and it could make a real mess of your phone and your privacy (tinyurl.com/jpusr3n, PDF). Further, the concept of public charge stations injecting malware has been around since 2011.

JUICE JACKING

The technique has since been dubbed 'juice jacking' and essentially relies on the fact that a USB peripheral device comes with firmware that a computer is required to run when the device is first plugged in so that the computer knows what it is and what to do with it. Hacked firmware could allow the USB device to attack the host and inject malware to gain personal data. A USB charger with hidden USB firmware could try to initiate an attack on a phone through this channel. The first 'BadUSB' device was shown at the Black Hat USA conference in 2014. BadUSB2.0 appeared earlier this year (tinyurl.com/jctmb3j). Both Apple and Android have since introduced mitigation steps to prevent such attacks, but when it comes to malware, nothing appears future-proof.

Right now, peripheral chip makers have begun launching new USB PD3.0-ready controller chips, such as Cypress Semiconductor's EZ-PD CCG3 — we think this means PD3.0-ready phones will begin appearing during the second-half of 2017 (tinyurl.com/jrgd78y).

DO YOUR HOMEWORK

Pretty much all of us have needed a second charger or cable for a phone or tablet at some point. But now with USB Type-C, there's a much greater need to do your homework before you buy. The new Power Delivery 3.0 standard should go a long way to solving issues, but we could be a while away before PD3.0-ready phones and chargers arrive. With an almost dizzying number of power standards now available, correctly matching chargers and phones is becoming more complex.

USB charging standards aren't the most exciting tech news you'll read all day, but next time you come across a dodgy cable or charger, we bet you'll be glad you did. ■

The USB-IF is setting up a USB charger certification program.

Taking Arduino to 32-bit

Eventually, eight bits just aren't enough. Darren Yates looks at various options for taking your projects to 32-bit performance.

Ardduino has become a popular maker platform for a whole range of reasons, not least of which is its simple, low-cost 8-bit processing. As we've seen over the last three or so years in our Arduino Masterclass series, there's plenty you can do with 8-bit processing when you're not encumbered by a lumbering operating system. But eventually, your ideas will get to the point where 2KB of RAM isn't enough and you just need more speed. That's when it's time to make the jump to 32-bit.

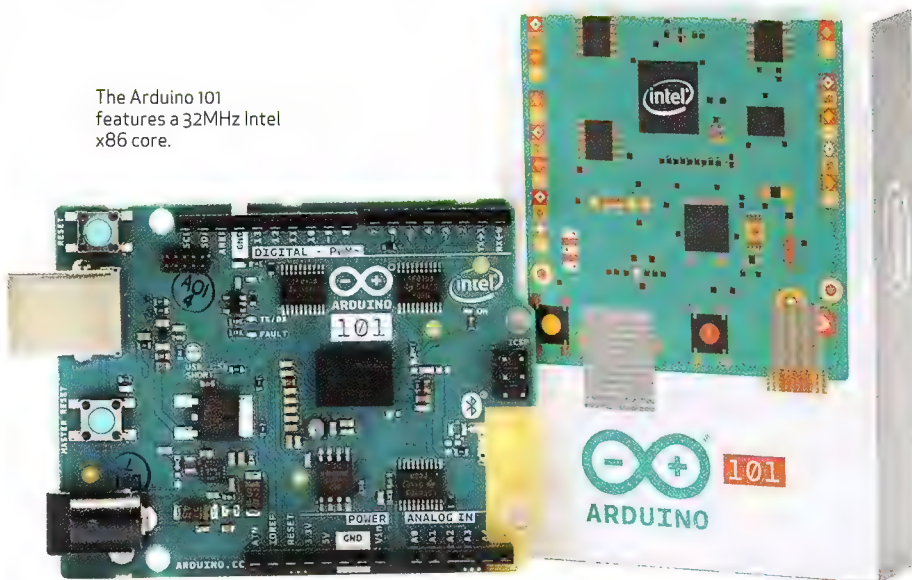
OFFICIAL OPTIONS

We've spent plenty of time concentrating on the Arduino Uno and its smaller sibling, the Arduino Nano, but the Arduino developers have been busy modernising their boards in recent times and there are now a number of 32-bit Arduino options available.

ARDUINO DUE

The cheapest and oldest of these is the Arduino Due. It's the same size as the Arduino Mega we used in a Digital Audio Recorder Mk II project (tinyurl.com/hd64wqp), but comes with Atmel's considerably-faster 84MHz SAM3X8E ARM Cortex M3 microcontroller. Officially, the Arduino Due is end-of-life now, but you'll still find clones floating around eBay for around \$20. The SAM3X8E has 96KB of RAM split into two banks, 32KB and 64KB, plus 512KB of flash storage for your code.

The Arduino 101 features a 32MHz Intel x86 core.

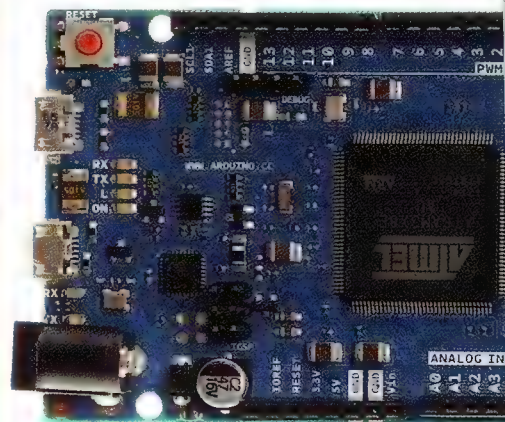
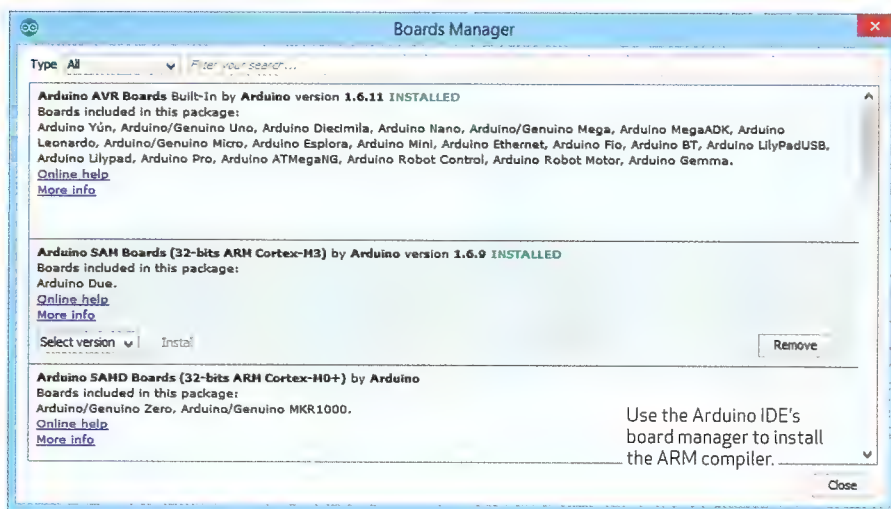


You get the same 54 digital I/O pins as the Mega, but it also comes with two 12-bit digital-analog converters (DACs). One of the more popular starter projects for the Due is to turn those DACs into a pseudo-16-bit stereo audio player.

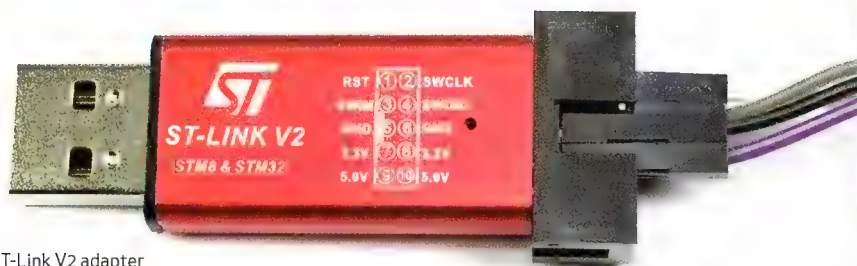
Unfortunately, the Arduino Integrated Development Environment (IDE) v1.6.9 no longer includes the Arduino Due compiler by default – you have to install it separately. To do this, go to the IDE (get it from arduino.cc) and from the menu, select 'Tools > Board > Boards Manager', choose 'Arduino SAM boards', and press the Install button. This downloads in the ARM compiler to build your code.

ARM CORTEx M-SERIES

However, what's really cool about 32-bit is the ready availability of ARM Cortex M-series microcontrollers – these are the little cousins to the Cortex A-series 'System on a Chip' (SoC) that powers your Galaxy S7 smartphone. In fact, the original Google Glass was powered by Texas Instruments' dual-core Cortex A9 OMAP4430 SoC – inside that chip are two Cortex M3 cores handling imaging subsystem (ISS) signal processing. The Fitbit Flex and Fitbit One fitness trackers are also powered by a Cortex M3 core. We might not be quite building the next Apple iPhone here, but we're definitely now at the grown-ups' table.



The 32-bit Arduino Due has gone end-of-life, but clones are still available.



The ST-Link V2 adapter programs STM32 boards via USB.

ARDUINO 101

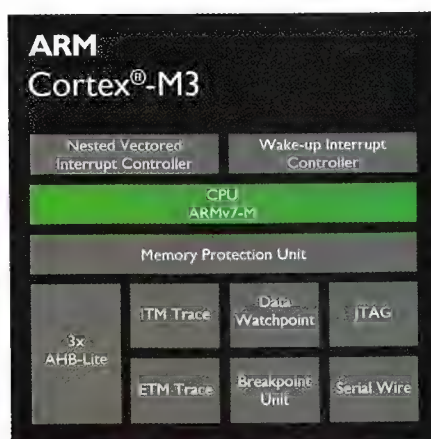
The **Arduino 101** is the first entry-level 32-bit board designed with the old Arduino Uno form factor. It features two cores – a 32-bit Intel Quark x86 core, plus a 32-bit ARC core, both clocking in at 32MHz. The board also includes Bluetooth LE and a six-axis accelerometer/gyroscope ready to go, making it an all-out Internet of Things (IoT) board. Support for the 101 is available in the latest Arduino IDE – just select the board type and the Intel compiler inside the IDE goes to work. You'll find the 101 for about US\$30.

UNOFFICIAL OPTIONS

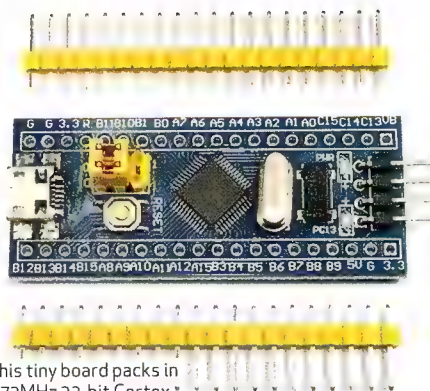
The rise of IoT really has lit a fire under the maker movement and the push for faster, cheaper microcontrollers is on in earnest. Back in 2010, a group called LeafLabs came out with an unofficial Arduino Uno-style clone called the Maple, built on a 72MHz 32-bit Cortex M3 chip from STMicroelectronics called the STM32F103R8T6. The group later released a Nano clone called the Maple Mini using the smaller STM32F103C8T6 chip. What was unusual about these boards is that, despite their 32-bit chips, you could code them using a modified version of the Arduino IDE, rather than more complex options. While LeafLabs no longer makes the Maple range, the design files are now open-source and eBay is flooded with Maple Mini clones you can pick up for just \$5.

Arduino boards, those claiming to be Arduino-compatible and even the Maple series have 'bootloader' software preinstalled. It's kind of a basic input/output system (BIOS) that tells the board how to communicate with the Arduino IDE over USB. These newer 32-bit Cortex M3 no-name boards don't have this bootloader and you need the ST-Link V2 USB adapter to code them.

A couple of years ago, Roger Clark, an Australian software engineer, started looking at these clone boards. The arrival of the Arduino Due led Arduino to make available an ARM Cortex M-series code compiler for the official Arduino IDE and, to cut a long story short, Clark has built up a thriving



ARM's Cortex M3 microcontroller powers the Fitbit Flex/One fitness devices.



This tiny board packs in a 72MHz 32-bit Cortex™ M3 chip for under \$5.

community getting these STM32 boards working on the Arduino IDE called **Arduino for STM32** (stm32duino.com).

DIFFERENT SPECS

The STM32F103C8T6 chip on these no-name boards has different specs to the Due's SAM3X8E. This particular version of STM32F1 runs at 72MHz, has only 20KB of RAM and 64KB of flash storage. There are many different chips based on the Cortex M3 core, but to get compatibility with the Arduino IDE, you need support libraries to enable the IDE to recognise and code each chip correctly. Chipmaker GigaDevices has developed a Cortex M3-based GD32F103 chip that runs at 108MHz and reportedly overclocks to 120MHz. This probably doesn't sound particularly fast for a CPU, but when the fastest microcontroller, the new ARM Cortex M7, only clocks at 300MHz, it's plenty quick – particularly given it's not dragging a full-on operating system behind it.

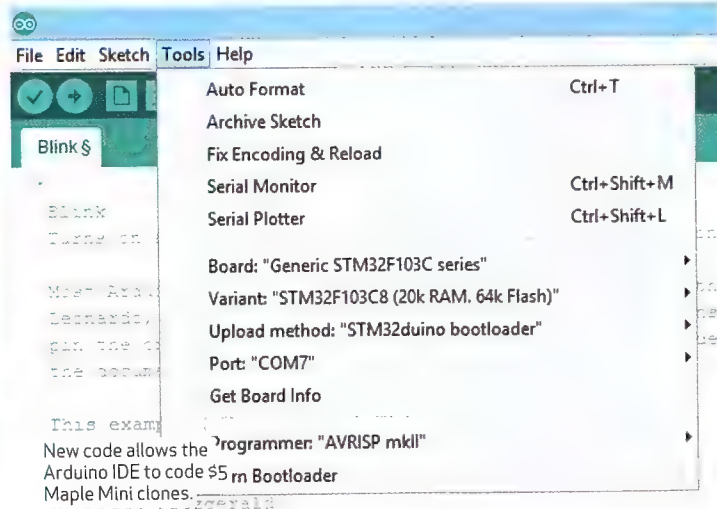
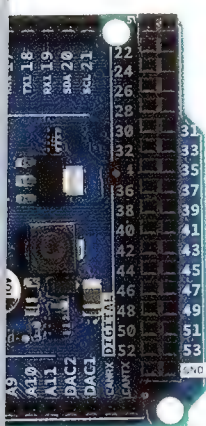
VOLTAGE WARNING

The key thing to remember when you make the move from 8-bit to 32-bit is that all 32-bit boards run on a lower 3.3-volt power rail, not the 5-volts the Arduino Uno, Nano and Mega boards use. This is important because feeding 5V into an I/O pin on some 3.3V boards may well blow them up. The Arduino 101 is unusual in that its I/O lines are 5V-tolerant. If you're using Arduino-based peripheral boards, you'll need to first check that they work at 3.3V, otherwise they may not start at this lower voltage.

A NEW CHAPTER

Making the hyper-jump from 8-bit Arduino to 32-bit ARM Cortex M-series boards will mark a new chapter in your learning, no question. It may seem daunting at first, but the basic principles are still the same — you come up with an idea, design the project, interface electronic components with the controller, flash your code and power on. The difference now is that you have much more processing horsepower at your disposal.

As we said, you're definitely at the grown-ups' table now. ■



Learn Python – Part 4: The ins and outs of functions

This month, Darren Yates looks at how to group code together to form code blocks called functions.

One of the key practices when writing code is always looking for ways to make your code more manageable, more readable and more modular. So far, the Python code we've written hasn't been all that long, but even with branching and loops, the code has always been just one big chunk. As your apps become more complex, having a single big chunk of code is a sure-fire way of running into trouble, particularly if you need to make changes or fix bugs. The solution to this in Python is to use what's called 'functions'. In Java, they're called 'methods' and, in BASIC, they're 'procedures'. Essentially, however, they all pretty much do the same thing – they allow you to create code blocks you can then execute by simply calling the function name.

FUNCTION BASICS

Functions might seem complicated to use, but really, they're dead-easy – you just need to understand how they work. At the most basic level, you create a function using just one line of code:

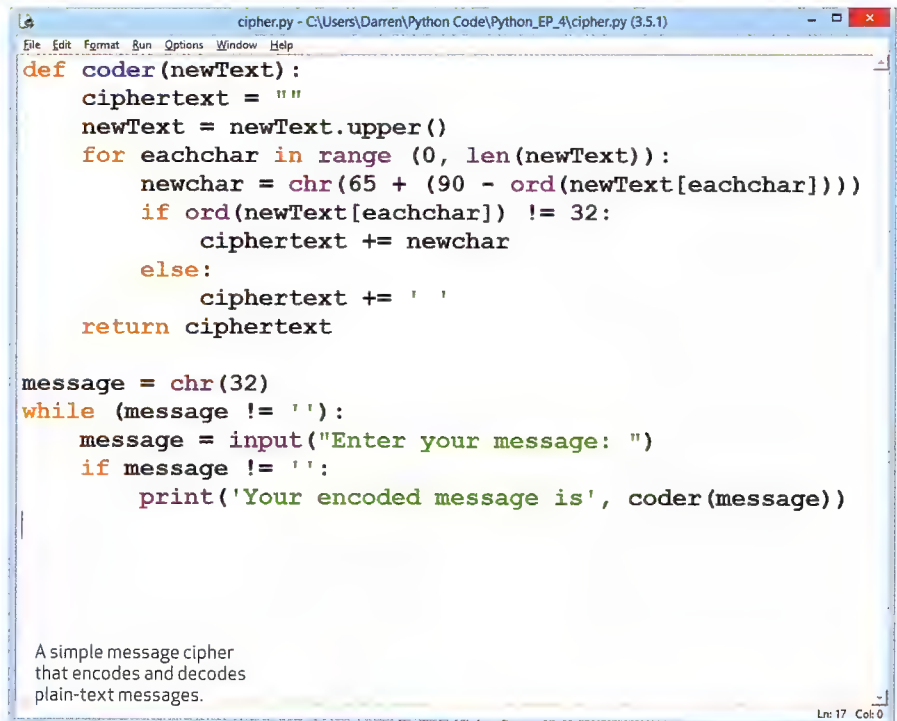
```
def functionName():
    statement_1
    statement_2 etc.
```

The 'def' line defines the start of a function code block – we'll get to what the parentheses '()' do in a moment. After that, you just enter in your code statements as before as you wish Python to execute them – the only thing is that each code line in the code block must start with at least one tab-key indent. But to get Python to execute the function, you simply call the function by its name:

```
functionName()
```

That's it. Simple. Let's give it a go. The app 'funcl.py' is a super-simple function:

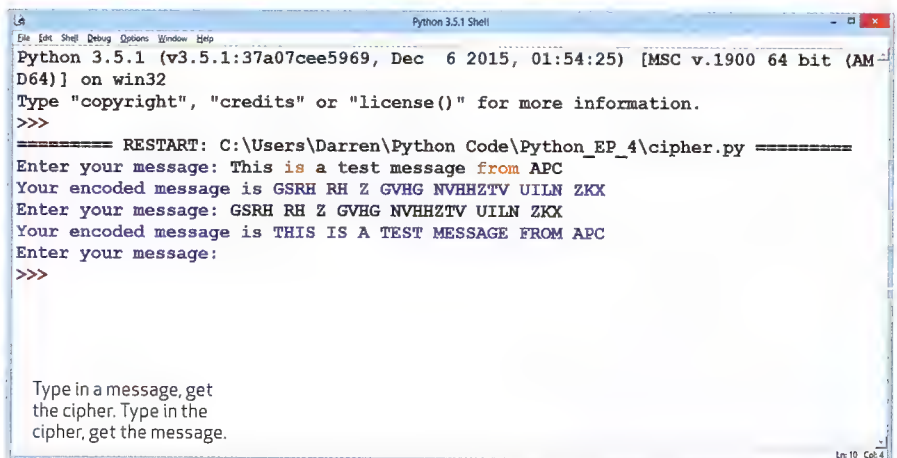
```
def helloWorld():
    print('Hello world-')
    print('from APC magazine!')
helloWorld()
```



```
def coder(newText):
    ciphertext = ""
    newText = newText.upper()
    for eachchar in range(0, len(newText)):
        newchar = chr(65 + (90 - ord(newText[eachchar])))
        if ord(newText[eachchar]) != 32:
            ciphertext += newchar
        else:
            ciphertext += ' '
    return ciphertext

message = chr(32)
while (message != ''):
    message = input("Enter your message: ")
    if message != '':
        print('Your encoded message is', coder(message))
```

A simple message cipher that encodes and decodes plain-text messages.



```
Python 3.5.1 Shell
Python 3.5.1 (v3.5.1:37a07cee5969, Dec 6 2015, 01:54:25) [MSC v.1900 64 bit (AMD64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: C:\Users\Darren\Python Code\Python_EP_4\cipher.py =====
Enter your message: This is a test message from APC
Your encoded message is GSRH RH Z GVHG NVHHZTV UILN ZKX
Enter your message: GSRH RH Z GVHG NVHHZTV UILN ZKX
Your encoded message is THIS IS A TEST MESSAGE FROM APC
Enter your message:
>>>
```

Type in a message, get the cipher. Type in the cipher, get the message.

We start by defining the function called 'helloWorld', whose code block includes two print statements. Then the actual app itself is just the line to execute the function, which is simply to call the function's name 'helloWorld()'.

PASSING VALUES TO A FUNCTION

Now let's say we want to pass a value (called an 'argument') to a function to do something with it. For that, you define the function to have a

parameter. Imagine you're a taxi driver – if you're going to convey passengers, you need a vehicle that has a seat for each person you convey. These parameter variables are those seats. Here's an example:

```
def multiply(var1, var2):
    print(var1, 'x', var2, '=',
          var1*var2)
    multiply(7,9)
    multiply(12,11)
```



```
func1.py - C:\Users\Darren\Python Code\Python_EP_4\func1.py (3.5.1)
File Edit Format Run Options Window Help
def helloWorld():
    print('Hello world,')
    print('from APC magazine!')
helloWorld()

Defining a function is easy
— just one line to define
and call to execute.
```

```
Python 3.5.1 Shell
Python 3.5.1 (v3.5.1:37a07cee5969, Dec 6 2015, 01:54:25) [MSC v.1900 64 bit (AMD64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: C:\Users\Darren\Python Code\Python_EP_4\func1.py =====
Hello world,
from APC magazine!
>>>

Functions execute code
just as Python does
normally.
```

```
factorial.py - C:\Users\Darren\Python Code\Python_EP_4\factorial.py (3.5.1)
File Edit Format Run Options Window Help
def factorial(varNum):
    result = 1
    for newValue in range(1, varNum+1):
        result = result * newValue
    return result
answer = factorial(6)
print('The factorial of 6 is', answer)

You can create your own
mathematical functions
like factorial.
```

What we've created is a simple multiply function that takes any two numbers, multiplies them together and show the multiplication in a print statement. Note the 'var1, var2' inside the function define's parentheses — these are the parameter variables, the variables the arguments will pass through. These variables are then used in the function code block to reference the values being passed to the function.

You can see this in the last two function-call statements — multiply(7,9) and multiply(12,11). These values map to the 'var1' and 'var2' variables so that in the first call, the '7' is passed to variable 'var1' and the '9' goes to 'var2'. In the second call statement, the '12' goes to 'var1' and the '11' to 'var2'. Hopefully, you can see the importance of getting the arguments and the parameter variables in the right order.

```
Python 3.5.1 Shell
Python 3.5.1 (v3.5.1:37a07cee5969, Dec 6 2015, 01:54:25) [MSC v.1900 64 bit (AMD64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: C:\Users\Darren\Python Code\Python_EP_4\factorial.py =====
The factorial of 6 is 720
>>>

Functions give you the
freedom to structure
your code.
```

Download the code

Here's what you'll need for this month's masterclass:

Source code - <http://apcmag.com/magstuff>

Python 3 - <https://www.python.org/downloads>.

Otherwise, your apps won't work properly. The other thing is you must have a parameter variable for every argument you pass — the number of parameter variables must match the number of arguments. Again, otherwise, Python gets stroppy and (rightly) chucks an up error warning.

RETURNING VALUES FROM A FUNCTION

You might remember we talked originally about how coding follows a simple concept of 'input, process, output' or IPO. Functions themselves can perform this role. So far, we've covered the 'process' and the 'input', so let's look at how to get a value back out from a function. This is nice and easy, too — you just add a 'return' statement at the end of your code block, followed by the variable whose value you want to send back.

If we rewrite our multiply function, we can make it more useful:

```
def multiply (var1, var2):
    return var1*var2
print('The answer to 7 x 6 is', multiply(7,6))
print('but the answer to 12 x 11 is', multiply(12, 11))
```

A couple of things to note here. First, the return statement of the multiply function contains the actual multiply function. Python knows to first process the return statement's function, hold the result and send it back through the return link. You can do this for short commands and it saves having to declare a temporary variable to store the multiplication result. The second thing is that having the multiply() function in this form lets us get more creative with the print statements. Having the print statement inside the function limits what you can do with it — every function run effectively has the same result. But having the print statement outside the function gives you the freedom to do what you like with it.

Let's expand this a bit and create a function that calculates the factorial of an integer number (that's where you multiply all of the numbers together starting from one up to your integer number):


```
def multiply(var1, var2):
    return var1*var2
print('The answer to 7 x 6 is', multiply(7,6))
print('but the answer to 12 x 11 is', multiply(12,11))
```

The return statement lets you grab the output from a function.

```
Python 3.5.1 (v3.5.1:37a07cee5969, Dec 6 2015, 01:54:25) [MSC v.1900 64 bit (AMD64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: C:\Users\Darren\Python Code\Python_EP_4\mult2.py =====
The answer to 7 x 6 is 42
but the answer to 12 x 11 is 132
>>> |
```

Using the function output gives you more freedom.

```
def multiply (var1, var2):
    print(var1, 'x', var2, '=', var1*var2)
multiply(7,9)
multiply(12,11)
```

Functions make repeating code much easier to understand.

the number's factorial. Here's one way it could look:

```
def sum_fact(varNum):
    factResult = 1
    sumResult = 0
    for newValue in range(1, varNum+1):
        factResult *= newValue
    sumResult += newValue
    return sumResult, factResult
ansSum, ansFact = sum_fact(b)
print('The factorial of b is', ansFact)
print('but the sum of integers 1 to b is', ansSum)
```

We start by defining the function 'sum_fact', we set up two variables, 'factResult' and 'sumResult'. We then initialise the for-loop as before and this time, we use the augmented operators to shorten the code. The last line of the function is key – we use the one return statement to return both answers at the same time. The next line is also important – we declare two new variables 'ansSum' and 'ansFact' to receive the output from the sum_fact() function. Again, order is important as well – in this example, the value from sumResult is assigned to the variable 'ansSum' while the value of 'factResult' is loaded into variable 'ansFact'. We then finish off with these variables in two separate print statements.

In theory, there's no limit to the number of return parameters you can have; however, just as with parameters and passing arguments, the same rule applies here – the number of receiving variables must match the number of returned values. Otherwise, you'll destroy the space-time continuum (well, your code will crash at any rate).

LOCAL VERSUS GLOBAL VARIABLES

This last function also helps to show something that divides opinion – the concept of local and global variables. When you define a variable, it has what's called a 'scope' within your program, or how far it is seen by the various parts of your code. Up until this month and our look at functions, every variable we've declared in our

```
def factorial(varNum):
    result = 1
    for newValue in range(1, varNum+1):
        result = result * newValue
    return result
answer = factorial(b)
print('The factorial of b is', answer)
```

First, we define the function 'factorial' with one parameter 'varNum'. Inside, we initialise a variable 'result' and create a for-loop that ranges from one (1) to the value of 'varNum' (we have to add one in this case because the range function always stops one short). We take each 'newValue' in that range, multiply it by the current value of the 'result' variable and store the result back in the 'result' variable. We then return that value back to the calling function. The next line shows you can assign the output of a function to another variable – here we're saying we want the factorial() function to

calculate '6-factorial' and dump the result into the variable 'answer'. We then use that 'answer' value in the final print statement (we could also just print the factorial(6) function result directly).

RETURNING MULTIPLE VALUES

Now you can return more than one value from a function – this isn't something you normally see in other programming languages, so it's a nice 'have' here. For example, say we wanted a function that provided both the sum of the integers to a number, as well as

```
Python 3.5.1 (v3.5.1:37a07cee5969, Dec 6 2015, 01:54:25) [MSC v.1900 64 bit (AMD64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: C:\Users\Darren\Python Code\Python_EP_4\multiply.py =====
7 x 9 = 63
12 x 11 = 132
>>> |
```

Functions perform their code the same each time.

code has been 'global' in scope because with only a single chunk of code, every line could see a variable if required.

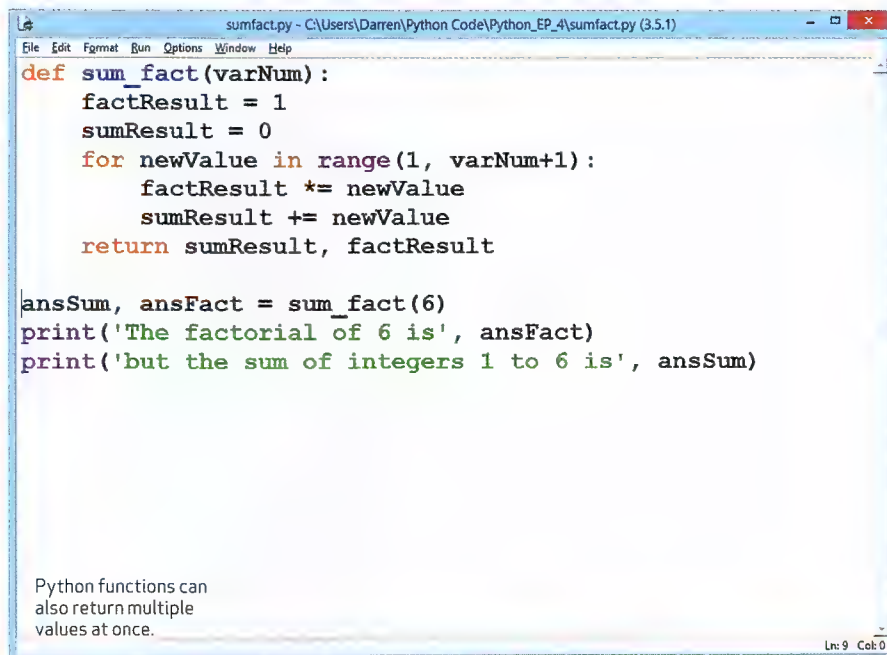
However, when you bring in functions, you now create different areas of scope. Inside the `sum_fact()` function, we created two variables 'sumResult' and 'factResult'. Because these are defined within the function, we say that their scope is only within that function. Or in other words, you can't see a local variable outside of its function – and this is actually a very, very good thing. Why? Because it allows functions to act as distinctly separate blocks of code where you can determine how the output of that function is accessed. If local variables were global in scope, you could mistakenly access local variables from anywhere in your code, which could lead to anarchy. But by keeping local variables with only limited scope, you control the flow of data more discretely through parameter variables and return statements.

In Java, for example, you can declare a global variable by simply initialising it at the start of a class – any code within a method in that class can see that variable. The same goes for Python as well – any variable initialised outside of a function is a global variable. But the difference here is that by default, global variables are not visible within functions without first declaring it global in that function by using the 'global' identifier.

SIMPLE TEXT ENCRYPTION

To finish off this month, we're going to build a really simple text encryption app. Type in a message and it'll create an encoded version for you to use. Enter that encryption back into the app and it'll turn it back into the plain text. We used this example in our Java masterclass as well, but it's important to see that you can often perform the same task in many different languages.

The first thing we do is define a function called 'coder', which takes one parameter called 'newText'. Next, we take the character string stored in 'newText', force it into uppercase text and dump it back into the 'newText' variable. The reason we do this is so we can be sure that we end up with alphabet characters that match a specific section of the ASCII character code. ASCII (American Standard Code for Information Interchange) is an international standard for converting alphanumeric characters into numbers. For example, the ASCII code for 'A' is 65, 'B' is 66 and so on through to 'Z' at 90.

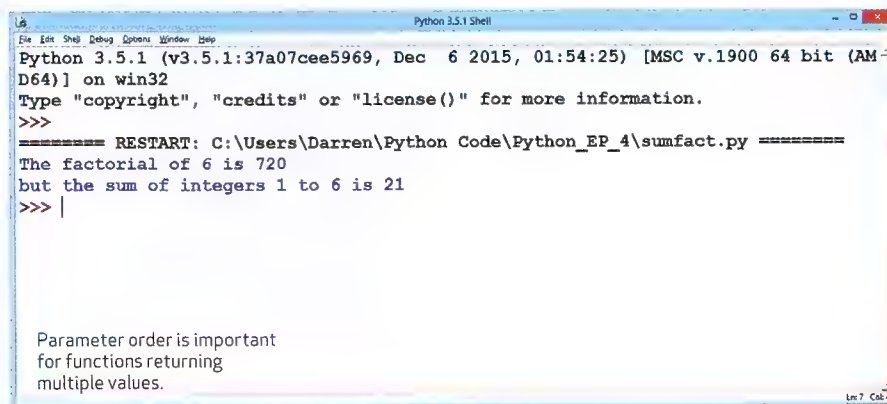


```
sumfact.py - C:\Users\Darren\Python Code\Python_EP_4\sumfact.py (3.5.1)
File Edit Format Run Options Window Help
def sum_fact(varNum):
    factResult = 1
    sumResult = 0
    for newValue in range(1, varNum+1):
        factResult *= newValue
        sumResult += newValue
    return sumResult, factResult

ansSum, ansFact = sum_fact(6)
print('The factorial of 6 is', ansFact)
print('but the sum of integers 1 to 6 is', ansSum)
```

Python functions can also return multiple values at once.

Ln: 9 Col: 0



```
Python 3.5.1 Shell
Python 3.5.1 (v3.5.1:37a07cee5969, Dec 6 2015, 01:54:25) [MSC v.1900 64 bit (AMD64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: C:\Users\Darren\Python Code\Python_EP_4\sumfact.py =====
The factorial of 6 is 720
but the sum of integers 1 to 6 is 21
>>> |
```

Parameter order is important for functions returning multiple values.

Ln: 7 Col: 4

Now in the for-loop, we set the range to be the length of the message in characters, since we need to process the message one character at a time. The next line looks quite complex, but what we're doing is basically 'flipping' each character, so if the character was original an 'A', it becomes a 'Z', 'B' becomes 'Y' and so on. Python's `ord()` function gives us the ASCII code for a character, while the `chr()` function turns the ASCII code back into a string character. The if-else statement looks out for spaces (ASCII code 32) – we want to preserve these as they are, so if the 'in-coming' character is a space, we just add it straight to the ciphertext variable. If it's not a space, we take the newly-converted newchar character and add that instead. When the message has been completely processed, we return the ciphertext back to the calling function.

The second part of the app consists of just five lines – we start initialising the message variable by putting a space character in it. Then while the message variable is not empty, we ask the user to type in a message, store it in the 'message' variable and, if that variable

isn't empty, we print out the coded version. This loop continues until the user just presses the Enter key with no message and the app quits.

SHA3 it certainly isn't, but it's simple, quick and you use the same function to encode a message and decrypt the message back into the plain text. That makes this a 'symmetrical' cipher because it self-reverses or inverts.

PYTHON IS BUILT ON FUNCTIONS

Functions are the building blocks of Python. In fact, Python's built-in libraries or 'modules' are essentially just great piles of functions. This means you can create your own functions for almost anything and build your own modules. It's one of the reasons why Python has become so popular for everything from data science to building your own Linux distro.

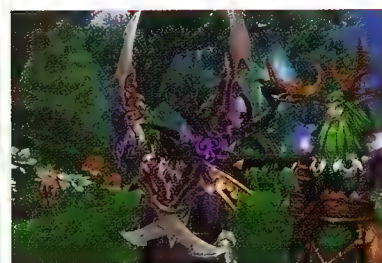
Even with just these four parts to our Python masterclass, you're well on your way to being able to develop seriously complex Python code. Next time, we'll get stuck into arrays, lists and start getting all mathematical. ■

downtime

» GAMES EDITED BY TROY COLEMAN

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World of Warcraft: Legion

Sets the stage for one of the most memorable chapters in its history.

Legion bears a terrible weight. In some ways, it feels like an apology for the mistakes made during the previous *WoW* expansion, *Warlords of Draenor*. Those mistakes led many to believe the MMO's days were numbered. Now *Legion* is tasked with not only making up for lost time, but also proving that *World of Warcraft* still has time left. Despite all this, *Legion* is the most confident expansion Blizzard has ever made.

The Burning Legion's invasion of Azeroth might be one of the most dire conflicts explored in the game, an impression driven home by the intro that pulls a few pages from *Game of Thrones* in nonchalantly killing off important characters. But that confidence I see in *Legion* doesn't just come from the story — it comes from understanding that this is Blizzard's sixth expansion. As I imagine

the Lord Illidan would say, they are prepared.

The pre-expansion introduction to *Legion* starts and — if you're with the Alliance — ends with a bang, but I was a bit disappointed that it didn't keep up that D-Day-style tension beyond its opening chapter. I was let down at first, but once I ventured out into the new zones and began digging into their questlines, I hardly cared.

Each of the new zones demonstrates Blizzard's experience in storytelling and world design at its best. They're gorgeous, and effortlessly funnel me from one quest to the next. The rainy coastline of Azsuna is my favourite. The crumbling elven ruins dotting its sombre landscape evoke a sad beauty. The quest about the ghost of a prince seeking redemption is just as tragic. A generous sprinkling of voice acting and cutscenes throughout these quests

help me sympathise with characters I fight alongside.

It's almost odd that things seem bleak when, at the same time, I'm having fun. At their heart, the quests in *Legion* remain focused on collecting and killing, but each one takes a chore and turns it into a game of charades where you never know what you're expected to do next. Where there isn't a unique wrinkle, such as using a squadron of drakelings to destroy defensive towers while an insane mage rains magic missiles on my head, there's some oddball character stuck in some bizarre predicament, like the pack of stranded sailors being used in *Pokémon* battles by giants. Even a simple escort quest became delightful when the scheming, mana-addicted elf I rode with had to frequently stop to feed his cravings.

There are times when *Legion* is outright silly, injecting a wonderful sense

of personality into its characters. I don't see a question mark on my map as a chore to be completed on my quest to level 110, but as an invitation for fun.

The world quest system is a smart revamp of daily quests that should keep *Legion* from feeling stale. They're essentially *Diablo III: Reaper of Souls'* adventure mode stitched onto *Warcraft*, and turn the entirety of the Broken Isles into an endgame zone at 110.

STAYING CLASSY

Still, questing for hours on end can be a grind no matter how inventive the quests, so I'm always relieved when *Legion* gives me an excuse to take a quick break. Tending to the new order halls that serve as my headquarters breaks things up every few hours. In the most reductive sense, order halls are the garrisons of *Warlords of Draenor*. While I still have followers I send out on missions that can take



Some order halls have extra perks: the Dreamgrove has portals to various locales.



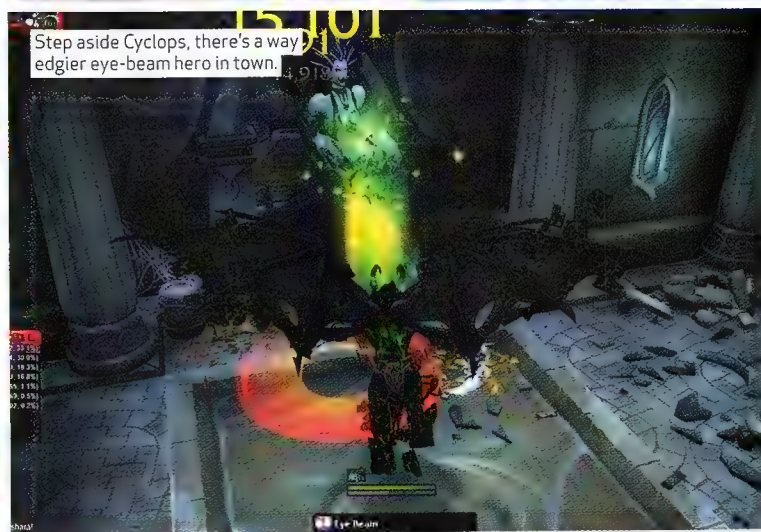
Druids' artefact weapons also alter their shapeshifted forms.



Stormheim: a bleak coastal zone populated by totally-not-Vikings.



A slight update to WoW's lighting works wonders in some areas.



Step aside Cyclops, there's a way edgier eye-beam hero in town.

days to complete, there are only five to manage instead of dozens. I like not having to worry about erecting and levelling buildings, instead investing in a simple, more focused system of researching new upgrades to my base. Best of all, I'm no longer alone when I'm in my order hall as I was with garrisons. It's fun to return home and see all my druid brethren hanging out together.

While the functionality of order halls is great for establishing longer term goals, my favourite aspect represents something that WoW has lacked for years: class identity. Each order hall is unique to its class, and all evoke the associated mythos and personality in powerful ways. The Dreamgrove, which druid players call home, is an enchanting meadow that feels heavy with ancient mysticism. The Fel Hammer, the demonic spaceship where demon hunters kick back after a day of murder, is burning with nefarious green energy amid the gnashing of the demon prisoners chained to its walls.

Each class has a generous number of quests that help

further this renewed sense of identity. I love digging deeper into the lore of my druid, and many quests require abilities unique to my character, some that I'd never use in any other context. It's a great feeling to dust off an old spell for some clever use, but more than that, there's a selfish satisfaction in knowing I'm doing something not everyone else can.

There's no better way to see Warcraft's improved class identity than to take the new demon hunters for a spin. They are, without a doubt, the most well-realised class that Blizzard has ever created. I'm not fond of their dour emo nature, but that's easily ignored as my demon hunter transforms into a savage monstrosity and obliterates a pack of murlocs with laser beams shooting out of his damn eyeballs.

LEGACY & LORE

If there's one element of *Legion* that attempts to contribute to that fantasy but falls short, it's the new artefact weapons. Each class specialisation now has its own unique weapon that will stay with them until the next expansion, growing in

strength alongside the character wielding it. I'm somewhat indifferent to the way artefact weapons work, however. On one hand, I like that they earn their own form of experience points that I can use to unlock nodes in a talent tree, augmenting my abilities. On the other, I resent the way they attempt to appear legendary and one-of-a-kind when every other player of the same specialisation shares the same weapon. There are cosmetic options to alter the appearance of the weapon to make it more unique, but I'm not convinced it's a better system than the traditional method of farming better weapons from dungeons and raids. Fortunately, the disconnect that artefact weapons create isn't powerful enough to detract from the enthusiasm I have for what *Legion* accomplishes elsewhere.

When it comes to the enthusiasm and those accomplishments, however, there's one massive caveat: *Warlords of Draenor* had me just as excited at launch before Blizzard ignored it for over a year, leading to one of the darkest times in Warcraft's history. With the quality of questing,

order halls and restored class identity *Legion* provides, I feel optimistic that Blizzard is keen to win back my lost faith, but an expansion isn't wholly defined by its opening chapter – the following updates will determine how we remember it.

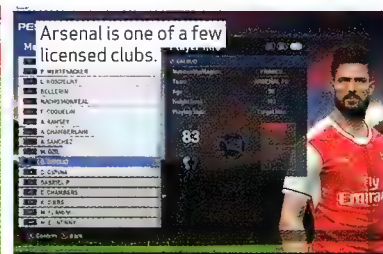
But while much of the endgame, such as raids and the 'Mythic+' dungeons, aren't available yet, *Legion* already represents WoW at its all-time best. Even after weeks spent in beta and now with the official release, its weakest elements, such as the artefact weapons, can't get in the way of how much fun I'm having exploring the Broken Isles. *Legion's* ultimate legacy may depend on what's to come, but what's available now has me excited about *World of Warcraft* in a way I haven't felt since my dwarf hunter took his first steps into Dun Morogh a decade ago.

■ Steven Messner

Verdict

If Blizzard can continue to deliver, *Legion* sets the stage for what could be the best chapter of WoW yet.





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Pro Evolution Soccer 2017

The PC version doesn't make the Premier League.

Like a football manager resting players for a second-rate cup game, Konami again appears to be treating the PC as a distraction from the main prize of console sales. *PES 2017* is another inter-generational hybrid that looks more like the Xbox 360 than the Xbox One game. It's an accomplished – brilliant at times – sim and an improvement on last season's effort, but it could, and should, be as good as the console game in every detail.

Get past this and you're in a happy, footbally kind of place. A place where subtle moments speak of a deep understanding in the fabric of the code of what makes the game of football so very beautiful. The AI is a perennial joy, and not just in terms of adaptive opposing players. Your virtual teammates are intelligent and appear sensitive to your desire for flowing football.

They are almost always switched on to the possibility of a defence-splitting pass, taking up positions that enable you to outclass your rivals.

There's also a quiet appreciation, especially if you turn off the poor commentary, for the joy of a long pass. It's something that's largely overlooked in the *FIFA* series, but that's the footballing equivalent of a sniper rifle headshot on a moving target – tricky, satisfying and fatal. Chipped through-balls and sprayed long passes are as relevant here as button-mashed dribbling skills.

All of which keeps matches ticking along nicely, something some online commenters claim breaks down during online play. That wasn't my experience. The main issue for me was the scarcity of opponents, with the only breaks in the flow of the game coming from sluggish advancement through CGI sequences –

an irritating drain on realism, but hardly fatal.

Hamstrung by EA gobbling commercial tie-ins for its *FIFA* series, licensed club, player and stadia names in *Pro Evo* remain few and far between. Wearside versus Man Red not only sounds naff, but it shatters the illusion of realism. Though the likes of Barcelona and their annual victims Arsenal are present and correct.

This is football with a brain and without the gloss. But there are moments of serious frustration, when a lack of footwork finesse causes play to break down needlessly. On the upside of unlicensed content, *PES* is largely immune to the fawning deference for big name players that is standard elsewhere. Rather than superstars appearing to belong to different species, the likes of Zlatan Ibrahimovic stand out, but don't dominate play. While his rapier-like shots aren't

automatic, your inadequate tap of the shoot button are modified by some cuddly power bar fairies to save the big man's blushes.

In other respects, *Pro Evo* remains true to its arcade roots. It's certainly one of the most 'gamified' football sims. The achievements system as you build a team in myClub mode features hundreds of rewards for feats such as signing new stars, or simply opening transfer negotiations.

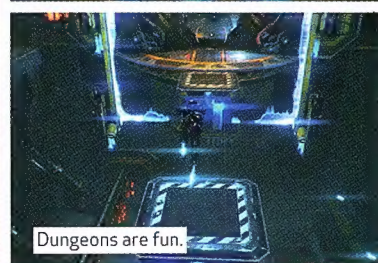
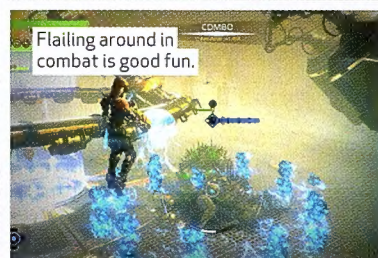
You can even earn contract extensions for managers for free by hitting performance benchmarks, otherwise you'll need to use up rewards or splash your cash.

■ Lee Hall

Verdict

A very good football game, but we're once again being fobbed off with a console-light experience.





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ReCore

Action platforming meets an empty desert world — with disastrous results.

ReCore spreads action platforming across a barren desert planet, so it works about as well as tennis on a football field. It's the skeleton of a springy 3D platformer tragically undernourished by an empty open world and a narrative that plays out like Asimov CliffsNotes. But what if robots were sometimes bad? The world is Far Eden, and all the people are missing. You must team up with a robot dog and search for answers.

But first, you'll need some Prismatic Orbs. Before that, you'll need to level up, and before that, you'll need to find some security bots buried in the sand, and before that, you'll need to trek across an empty desert. ReCore is an infuriating cycle of checklists and chores, suffocating its best design beneath miles of bloat. The classic 3D platforming part actually

works well. Platforms float in the sky without a wink toward the fiction, score multipliers litter the screen during combat, and shiny resources explode out of robot monsters — walk over them and *plink, plink, plink*.

It's dated, but it feels good. The jump and dash physics is dependable and easy to gauge. It has to be: most of the platforming dungeons you load into from the overworld are focused and challenging, even if they're made of featureless level design building-blocks. But there are only a handful of these sequences locked behind hours of boring collection quests.

Combat makes use of the same skills, and occurs in designated dungeon arenas and wherever there's sand, robots like to pop out of the ground without warning. Point the reticle near one and you can lock on for easy circle-strafing, a refreshing take on shooter design that shifts the

challenge from a test of accuracy to one of crowd management and acrobatics. These unfriendly robots fill the screen with projectiles that move just slowly enough for you to jump and dash around if you're capable of doing so.

You can sic your own robot pets on enemies, use charged shots on them, and extract their core once they're weak enough. Opponents appear in a variety of colours, and are only vulnerable to beams that match. ReCore's combat is good fun, but I grew tired of it over repeated treks across the same expanse of sand, as nice as it looks.

ReCore's action is good on its own, it's just completely diminished by an overworld that hides it away and chops it up with progress gates.

The vast sandscapes work well in characterising Far Eden as a young rimworld, but they're empty, with no vehicles and few fast travel checkpoints.

In one instance, I spent an hour scouring the desert for hidden security bots just to unlock a dungeon door. Once I got in and halfway through exploring it, I couldn't proceed because I wasn't a high enough level to defeat some enemies.

Then there's the endgame. The final objective is strung out into several floors of platforming and combat challenges, with each floor gated by five Prismatic Orbs. It reduces ReCore to an even more monotonous grind that takes as long as the campaign does until that point. With such little consideration for players' time, you're better off spending it elsewhere.

■ James Davenport

Verdict

Buries a great action platformer beneath layers and layers of open-world busywork on a barren world.





Not quite Kryten

The robot that folds your laundry for you.

While many of us are wary of the advances in AI (fearing the possible dystopian futures depicted in movies such as *The Matrix*, *Terminator*, *2001* and *Transcendence*), the reality of AI at present is rather less exciting (and deadly). Meet /laundroid1 – the bot who wants to fold your laundry. Created by Seven Dreamers Laboratories, with Panasonic and Daiwa House Industry, /laundroid1 grabs, spreads, recognises (in order to know how to fold), folds and sorts laundry into perfectly folded piles. All you need to do is throw all your clean clothes in the bottom compartment, then wait ten minutes or so for the folding to be completed. I don't know about you, but that's faster than my folding efforts!



Can't afford a new Mac?

MAKE DO WITH THIS 'NEW MAC SMELL' CANDLE INSTEAD.

Some people love the smell of old books, freshly mown grass, forests, sea breezes and rain on hot asphalt. Others go nuts over the smell of a new Mac, so many, in fact, that TwelveSouth has created an incense candle that – yep, you guessed it – gives off the scent of a new Apple computer. With hints of mint, peach, basil, lavender, mandarin and sage, you'd be forgiven for thinking you were reading about a wine, but make no mistake, this is the nerdiest candle ever made. So if you've got a hankering, you can purchase one for US\$24 – once they restock because, as we were going to print, they were sold out. It will burn for 45–55 hours, which may carry you over until the next Mac models are released.



Pull out

CONNECTED SEX TOY USE BEING CREEPILY TRACKED BY MAKER, US LAWSUIT CLAIMS.

The Internet of Things is a vast playground full of great, innovative tech, ranging from fridges to light bulbs, speakers to vibrators. Wait, what? You read right. The We-Vibe is a vibrator that can be controlled via an app on your smartphone — locally and also abroad (for those in a distance relationship, presumably). However, the maker of the sex toy has lately landed itself in some deep water after a Chicago woman took them to court over the "highly sensitive, personally identifiable information" it had been collecting about its customers. The company is accused of gathering the preferred settings, dates and times the device is used without the customers' knowledge, violating several US laws on consumer protection and privacy.

Don't panic

NOVEL VIDEOGAME WILL ONLY LET YOU WIN IF YOU STAY CALM.

Champions of the Shengha is a fantasy card battling game featuring all manner of creatures native to the genre (including a sword-wielding bird-headed warrior and a deer-headed, braid-flowing huntress). However, instead of relying on hours of experience, knowledge and skill, this game relies on the player's emotions. You're tasked with summoning your inner strength and controlling your emotions through breathing, and it's this mastery that gives you powers and gear in the game. A special ear clip tracks breathing and heart rate during play. But the game itself isn't the end product, for the creators of *Champions* wants this game to impact on players in their everyday lives, giving them the ability to better control their emotions and focus, and it appears to work. ■





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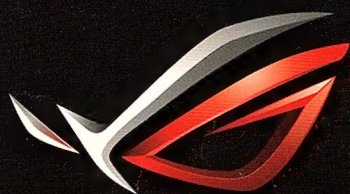
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